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BIOLOGY, INFESTATION CHARACTERISTICS AND IMPACT OF THE BAGWORM, *PTEROMA PLAGIOPHLEPS* HAMPS. IN FOREST PLANTATIONS OF *PARASERIANTHES FALCATARIA*

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The biology, infestation characteristics and impact of the bagworm, *Pteroma plagiophleps* Hamps. (Lepidoptera, Psychidae), a newly emerging pest of forest plantations of exotic *Paraserianthes falcataria* (= *Albizia falcataria*) (Mimosaceae) in Kerala, India was studied. With a generation time of 10-11 weeks, upto 5 generations per year have been observed in the field but outbreaks leading to heavy defoliation occurred only once or twice a year. The outbreaks occurred in small patches within plantations. In a 20 ha plantation of *P. falcataria* studied, repeated defoliation over two years and half caused death of 22 per cent of trees, and severe damage to 17%. Host preference tests and infestation characteristics of this polyphagous species feeding on several unrelated families showed 3 types of infestation: (1) heavy pest level infestation affecting a large number of trees of particular species in a patch within a plantation; (2) heavy infestation of isolated trees in natural areas leaving other trees of the same species in the vicinity unaffected; and (3) sparse. unnoticeable infestation of several species. Some evidences suggest that heavy infestation leading to outbreaks is dependent on host stress as exemplified by infestation of *Eucalyptus* sp. in SO_2-stressed environment.

(*Key words* : newly emerging pest, pest outbreak, defoliation, host preference tests, host stress, SO_2 stress)

INTRODUCTION

Paraserianthes falcataria (L.) Fosb. [Syn. *Albizia falcataria* (L.) Fosb.] (Mimosaceae) is a very fast growing tree species native to the eastern islands of Indonesia and to New Guinea (ANONYMOUS, 1979). Small scale plantations have been raised in India, mostly since the 1960's, in Assam, Tamil Nadu, Kerala and Andamans (GHOSH, 1977). The species has acquired increasing importance as a source of timber for 'Katamarans' (fishermen's floats), matchwood, plywood and pulpwood. In Kerala, most plantations have been raised since 1974, in blocks ranging from 10 to 100 ha which now total over 1000 ha, distributed mostly in the central and southern regions. Earlier we reported on 25 species of insects found associated with this tree in Kerala, of which the bagworm, *Pteroma plagiophleps* Hampson (Lepidoptera, Psychidae) was the most damaging (MATHEW & NAIR, 1985). An outbreak of this insect, known until then as a minor and occasional pest of the tamarind tree, *Tamarindus indica*, was first noticed in a *P. falcataria* plantation at Vazhachal in central Kerala in 1977 and by 1979 infestations spread to avenue plantings of *Delonix regia* over most of Kerala (MATHEW & NAIR, 1983; NAIR *et al.*, 1981). Apart from these reports, literature on this insect is limited to the original description of the species by HAMPSON (1892), a later description of the male moth by DIERL (1971), both based on moth collections from Sri Lanka; brief reports on its occurrence on tamarind (AYYAR, 1940), pomegranate (AIYER, 1944) and tea (DAS, 1956) and a recent report on variability in its wing

venation by one of us (MATHEW, 1985). Our observations and investigations since 1977 on various aspects of its biology, behaviour, distribution pattern within plantations, seasonal incidence and impact are reported here. Since the study pertained to a newly emerging pest situation, it was not always possible to undertake well planned systematic investigations. Therefore chance observations from several situations have also been used to build a broad outline of the characteristics of infestations.

MATERIALS AND METHODS

The results reported here are mainly based on observations in a 20 ha plantation of *P. falcataria* established in 1974 at Vazhachal, about 40 km east of Chalakudy along the Chalakudy-Sholayar road (10° 18'N latitude, 76° 35'E longitude, 447 m asl). The area, now surrounded by teak and eucalypt plantations, originally supported evergreen forest. Observations started with the discovery of bagworm infestation in April 1977 and continued over a 3 year period during which the plantation was visited once every month and qualitative observations on the status of infestation was recorded. In addition, detailed enumeration of infestation intensity or tree damage was made on some occasions. Some laboratory observations and experiments were also carried out using field-collected insects. Methods employed in specific aspects of the study are given below.

Life cycle:

Life cycle was studied using newly hatched larvae obtained from field-collected gravid females. The newly hatched larvae were transferred to potted 12–18 month old *P. falcataria* saplings maintained in outdoor cages. Only a few larvae survived to become adults: 3 out of 28 in one batch and 2 out of 14 in another; one from each batch was female. Most loss was due to wandering of young larvae out of the host saplings.

Intensity and spatial distribution of infestation:

To study the intensity and spatial distribution of infestation, all trees in every 20th row of the 20 ha plantation were examined and each tree was assigned a score of 0, 1, 2, 3 or 4, representing respectively nil, low, medium, high, or very high, infestation level based on visual estimate. Low level infestation was characterised by the presence of at least one larva or pupa visible from the ground, and very high level, by total defoliation. The survey was carried out about 3 months after the infestation was first noticed. To plot the spatial distribution of infestation intensity, the median score of each set of 4 consecutive trees in the row was marked on graph paper.

Seasonal population trend:

Generally, only a qualitative picture of the seasonal population trend was obtained. During the monthly observations, one of the middle rows of trees was examined closely for presence of the insect, by walking along the row. For some months a quantitative index of population was obtained by recording counts of insects as 10, 100 or 1000 per tree, indicating the lower limit.

Impact on trees:

The impact of defoliation was studied in two ways: (1) During the second peak of outbreak in July 1977 when the trees were 3 years old, a group of 22 trees (7-13 cm girth at breast height) which had suffered total defoliation, apparently for a second time, were marked at site and the status of these trees was observed two months later. (2) In March 1980, after 3 years

of repeated defoliation, 5 per cent of the trees in the 20 ha plantation (all trees in every 20th row) were examined and visually scored into one of five damage intensity classes.

Host range and preferences:

Host range was determined from general observations throughout Kerala over a period of several years since 1977. In addition, acceptance of and preferences among five plant species were studied experimentally using newly hatched larvae. Potted saplings of these species were kept inside screened cages, $1m^3$ both in isolation and in mixture and the newly hatched larvae were distributed equally into the cages as they became available, over a period of 3 weeks. The trial was replicated three times.

RESULTS

The life cycle:

In this species, the adult female is larviform and confined to the larval bag throughout life. Insemination is accomplished by the male moth alighting on the female bag and inserting its abdomen through the posterior opening of the bag. Copulation was observed to last about 15 min, with the male remaining in a suspended position. The fertilized eggs develop within the body cavity of the female which progressively degenerates and the bodywall ruptures finally to release the newly hatched larvae which disperse from the hanging bag, on silk threads. In one fortuitous observation, the period between mating and emergence of neonate larvae was found to be 12 days. This should approximately correspond to the incubation period. The eggs develop synchronously and the larvae eclose at the same time. From two field-collected females, we counted 110 and 202 newly hatched larvae.

Based on 3 females and 2 males reared on *P. falcataria* saplings, (Table 1) the mean larval period was 49 days for male (range 43–53) and 62 for female (range, 58–66). The mean pupal period of the male was 14 days (range 13–16); that of the female could not be determined as it is concealed within the larval bag. Including a period of 12 days from mating to egg hatching, the length of life cycle from egg to adult is

TABLE 1. Developmental period of *Pteroma plagiophleps* on *Albizia falcataria*.

Initial no. of larvae & date of hatching	No. pupated	Larval period (days)		Pupal period (days)		Larva to adult period (days)	
		Male	Female	Male	Female	Male	Female
28							
(14 Aug. 1977)	3	51	66	14	—	65	—
		53		16		69	
14							
(30 Aug. 1977)	2	43	58	13	—	56	—
	Mean	49	62	14	—	63	—

about 75 days for male. The length of life cycle of female could not be determined as the adults do not emerge. On several occasions, from field collected samples, male moths and neonate larvae emerged simultaneously or at close intervals suggesting that the longer larval period of the female may be compensated by a shorter pupal period. As a broad generalisation, the generation time of *P. plagiophleps* can be taken as 10–11 weeks.

The adult male with atrophied mouth-parts do not feed and lived for about 4 days in laboratory cages.

In the only other report on the life history of this species (originally reported as an undetermined *Pteroma* sp., *vide infra* for species identity), AIYER (1944) estimated a shorter larval period of 5 weeks (on pomegranate, *Punica granatum*) and a pupal period of about 2 weeks. He also reported a lower fecundity of 75–80 eggs per female.

Larval behaviour and nature of damage:

The newly hatched larvae, hanging on silken threads from tree branches, apparently get windblown. On landing, they walk briskly using the thoracic legs, with abdomen raised upright over the head. When observed in the laboratory on a leaf of *P. falcataria*, the newly hatched larva wandered along the main and secondary rachises for about 5 min and then settled on the under surface of one of the leaflets. Construction of the bag began immediately. Small pieces of leaf tissue were gnawed out from the leaflet and attached to the body posterior to the thorax, to form a complete ring. More pieces were then added to the anterior end of the ring to enlarge the bag until a complete tube was formed covering the body. Generally, the leaf bits were gnawed out without puncturing the leaf blade but rarely holes appeared. Sometimes the bits were taken from the leaf margin. After placing a leaf bit on to the ring, the larva moved its head briskly over it two or three times, apparently to attach it with silk. The bag was often found attached to the leaf with one or two fine threads of silk. Construction was completed in about an hour of initiation, and the larva walked off holding the bag upright. The posterior end of the tube remained open, and at this stage, the structure was more tubular than conical. The fresh bag was green in colour but turned brown when the leaf tissue dried up.

Generally, the larva feeds from the under surface of the leaflets. It consumes the epidermal layer and the mesophyll tissues containing the chloroplasts, leaving a thin layer of epidermis on the opposite surface. Generally, feeding is patchy, with some portions of each leaflet left uneaten (Fig. 1). In heavy infestation, each compound leaf may harbour hundreds of caterpillars. When the damage is extensive, the whole leaf dries up. Such leaves remain on the tree for some time, giving a scorched appearance to the tree.

Older larvae usually migrate to the branch stems and often to the main trunk, particularly when the population is large, and feed on the live surface layers of bark, leaving feeding scars (Fig. 2). Larvae resting or feeding on the stem, with their conical bags held at right angles to the stem, resemble thorns. Pupation usually occurs on the stem. Before pupation, the anterior end of the bag is closed and the bag is suspended on a thick silk thread attached to the stem (Fig. 3). In heavy infestations, trees suffer total defoliation (Fig. 4) and thousands of bags can be seen hanging from the branches.

Fig. 1. (Left) Feeding pattern of *P. plagiophleps* on the leaf of *Paraserianthes falcataria*. Note the characteristic patchy feeding on each leaflet. The thorn like projections on the main rachis are larval bags. Fig. 2. (Right) Stem of *P. falcataria* showing the bagworm larvae (inside bags which appear like thorns) and the feeding scars on bark.

Intensity and spatial distribution of infestation:

Fig. 5 shows the intensity and spatial distribution of infestation in a 20 ha plantation, 3 months after the infestation was first noticed. The frequency distribution of trees which suffered different levels of infestation is given in Table 2. About 10% of the trees were free of infestation, and at the other extreme, 8% were very heavily infested, suffering total defoliation. About half of the trees showed only low level infestation.

There were two foci of highest infestation from where the intensity decreased gradually towards the periphery (Fig. 5). Trees in these two patches suffered total defoliation. This infestation pattern, mapped in July 1977, about 3 months after the attack was first noticed (NAIR *et al.*, 1981) was the cumulative result of two population peaks the first in March-April and the

TABLE 2. Frequency distribution of infestation levels.

Infestation level	Percent of trees (Total 725)
Nil (Score 0)	10.3
Low level (Score 1)	51.2
Medium level (Score 2)	18.9
High level (Score 3)	11.4
Very high level (Score 4)	8.1

Fig. 3. (Above) *P. plagiophleps* pupae (inside cocoons made of larval bags) hanging from branches of infested tree. Fig. 4. (Below) General view of a bagworm defoliated patch of 3-yr old *P. falcataria* plantation at Vazhachal.

second in June-July 1977. Large populations of young larvae were seen in healthy trees around the defoliated patches in June. The clumped distribution shows that the second infestation was mainly confined around the first.

Seasonal population trend:

Since the observations were qualitative and limited to monthly intervals from 1977 to 1979, only the trend of population change could be determined.

Larvae and pupae were present on most observation dates. The numbers, however, varied widely. Two distinct outbreaks were evident in 1977, in early April and late June, which led to total defoliation of a large number of trees in two patches. A large number of larvae were found dead in early August 1977. Incidence of disease was suspected, and an undetermined fungal pathogen was found in subsequent samples. Presence of insect parasitoids was also noted. Evidence was obtained for at least two additional generations during the year and there was some overlapping of generations. However, no outbreak level population was built up. In the following year, outbreak populations were noticed in July and November and there was evidence of continuous generations at low population levels. Substantial larval mortality was observed in July. Insect parasites accounted for nearly 25 per cent of deaths in some samples. In 1979 outbreak populations were seen in January-February, and late March. In May, the population was controlled by spraying 0.1% lindane. Very small numbers of larvae and/or pupae were seen subsequently in August, November and December when systematic observations were discontinued. Another outbreak was noticed in February 1981, but since then no outbreak has come to our notice upto 1987. Outbreak populations were usually even-aged, although overlapping of developmental stages was common in non-outbreak populations.

These data lead to the following conclusions. Population outbreaks of the bagworm occurred every year during the three years. More than one outbreak may occur per year, but drastic population reduction is brought about during July-August by some natural control factor operating on larvae, upto 5 generations are possible per year.

Infestation in other P. falcataria *plantations:*

When the bagworm outbreak was first noticed in one of the plantations at Vazhachal in April 1977, several other plantations of *P. falcataria* in the State were surveyed to detect infestation, if any. These included about 78 ha of plantations raised between 1973 and 1977 at Vazhachal, Kollathirumedu and Kalady in central Kerala and a similar extent of plantations at Kulathupuzha and Punalur in southern Kerala. Except for the presence of a few stray larvae and pupae in a 10 ha plantation very close to the heavily infested 20 ha plantation at Vazhachal, no infestation was detected. Since then, irregular, but frequent observations were made in most *P. falcataria* plantations, either directly, or indirectly through the Forest Department. The next spread of outbreak was recorded in July 1978 in another 1974 plantation at Pachakkadu (10 ha), at a distance of about 5 km from the first affected plantation. Here again defoliation was clumped. Several other *P. falcataria* plantations in the Vazhachal region within a radius of about 15 km remained unaffected. By 1981, that is, in about 4 years since the first outbreak on *P. falcataria* at Vazhachal, large populations of the bagworm had built up almost throughout Kerala on *Delonix regia*. Later in the first half of 1984, outbreaks were

noticed in two plantations of *P. falcataria* in southern Kerala at Arippa near Kulathupuzha and Anakkulam near Punalur. In both plantations, a large number of trees suffered total defoliation, characteristically in patches. Other *P. falcataria* plantations in southern Kerala remained uninfested. More surprisingly, outbreaks have not developed in several plantations of *P. falcataria* located near infested plantations in Vazhachal, although outbreaks are now almost a regular annual feature on avenue plantings of *D. regia* along the highways.

TABLE 3. Impact of bagworm infestation in a *P. falcataria* plantation (20 ha) over 2.5 year period.

Tree condition	Percentage of trees (based on a sample of 1012 trees)
Dead	22
Upto 75% from top of the main bole dried up	7
Upto 50% from top of the main bole dried up	5
Upto 25% from top of main bole dried up	5
Healthy	61

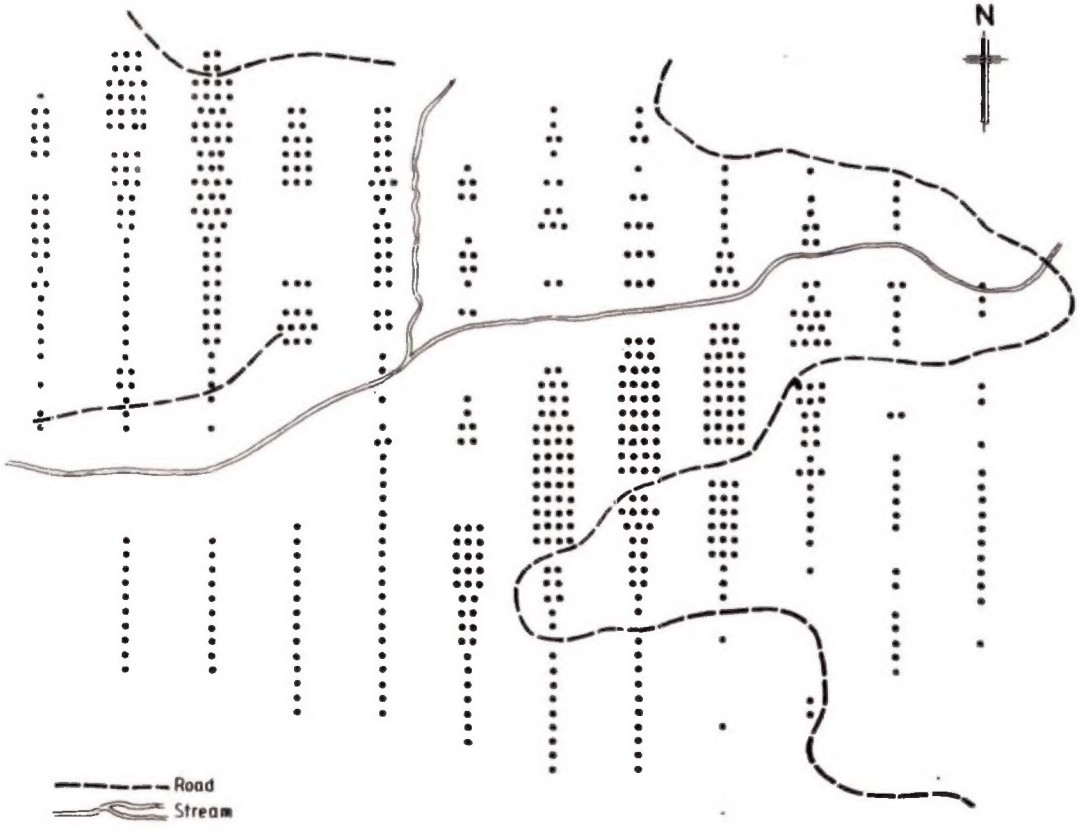

Fig. 5. Spatial distribution of bagworm infestation intensity in a 3-year old 20 ha *P. falcataria* plantation at Vazhachal. The intensity of infestation is indicated by the number of dots in a row, 4 dots representing very high intensity with total defoliation, and blank indicating no infestation. Each data point represents the median score of 4 trees in the row; every 20th row was scored.

TABLE 4. Host list of *Pteroma plagiophleps*.

Serial no.	Host	Region	Infestation characteristics
	Caesalpiniaceae		
1.	*Cassia biflora* L.	Peechi	Occasional, low level occurrence on some plants
2.	*Delonix regia* (Boj.)	Kerala	Occasional, heavy outbreaks on avenue trees (Mathew and Nair, 1983)
3.	*Tamrindus indica* L.	Southern India	Occasional minor pest (Ayyar, 1940); Rare, heavy infestation on isolated trees (Mathew and Nair, 1983)
	Cannaceae		
4.	*Canna indica* L. (canna)	Peechi	Rare, severe infestation on some plants
	Euphorbiaceae		
5.	*Emblica officinalis* Gaertn. (Gooseberry)	Vellanikkara & Peechi	Rare, heavy infestation on isolated trees
	Lauraceae		
6.	*Cinnamomum malabratum* (Burm. f.) Bl.	Sholayar	Rare, in natural forest trees
	Mimosaceae		
7.	*Paraserianthes falcataria* (L.) Fosberg	Kerala	Occasional, heavy outbreaks in plantations (Nair *et al.*, 1981)
	Myrtaceae		
8.	*Eucalyptus tereticornis* Sm.	Kalamasseri	Moderate level outbreak in a small plantation stressed by SO_2 pollution in the premises of Indian Aluminium Co.
9.	*Syzygium aqueriam* (L.) (Burm. f.) Alston	Trivandrum	Occasional, sparse occurrence
10.	*Syzygium cumini* (L.) Skeels	Trichur	Rare, heavy infestation on some trees
	Palmae		
11.	*Cocos nucifera* L. (Coconut palm)	Mannuthy	Rare, sparse occurrence
12.	*Chrysalidocarpus leutescens* Wendl. (Ornamental palm)	Mannuthy	Rare, severe infestation
	Punicaceae		
13.	*Punica granatum* L. (Pomegranate)	Trivandrum	Rare, heavy infestation on isolated trees (Aiyer, 1944)
	Salicaceae		
14.	*Populus deltoides* Bartr. (Poplar)	Peechi	Rare, medium infestation
	Theaceae		
15.	*Camelia sinensis* (L.) Fosberg. (Tea)	Assam	General sparse occurrence in plantations [(Das, 1956)]
	Ulmaceae		
16.	*Trema orientalis* (L.) Bl.	Trichur	Rare, heavy infestation on isolated tree
	Verbenaceae		
17.	*Tectona grandis* L. f.	Trichur Kothamangalam & Vazhachal	Occasional, sparse occurrence

Impact on trees:

In the 3 year old *P. falcataria* plantation, out of 22 trees examined (which had apparently suffered two total defoliations) 3 trees were dead and 6 trees were severely damaged, with the greater part of the main bole dried up and coppice shoots originating from the basal part of the trunk. The remaining trees (59%) were more or less healthy with only some of the smaller crown branches dried up.

Table 3 shows the impact of bagworms on the plantation as a whole, over a period of two and a half years until insecticidal protection was given. About 22 per cent of the trees were dead and 17 per cent dead in part. About 61 per cent of the trees were healthy. Most tree mortality was centred around the two patches where initial outbreaks had developed.

Host range and preferences:

The host plants of *P. plagiophleps* observed in this study are listed in Table 4, along with brief notes. For the sake of completeness a few previous records are also included.

Although *P. plagiophleps* accepted plants of several unrelated families, the infestation characteristics differred. Three categories were distinguished: (1) heavy, pest-level infestation affecting a large number of

TABLE 5. Survival of *P. plagiophleps* on different hosts in outdoor cage experiments.

Trial no. & parental host tree	Dates of larval release (80-81)	No.of larvae released in each cage	Date of final obser-vation	No. of insects that completed development or surviving on termination of expt. (P = Pupa; L = Larva)					
				Tamarindus indica	*Albizia falcataria*	*Delonix regia*	*Punica granatum*	*Syzygium aqueum*	All species, mixed
1 *Delonix regia*	24 Sept. to 17 Oct.	295	12 Dec.	20 P	1 P	Nil	—	—	1 P & 6 L on *T. indica*
2 *Delonix regia*	15 Dec. to 31 Dec.	71	11 Feb.	7 P 11 L	2 L	Nil	8 L	Nil	3 P & 1 L on *T. indica:* 5 L on *P. granatum*
3 *Albizia falcataria*	22 Dec. to 1 Jan	87	11 Feb	4 P 11 L	3 L	Nil	3 L	Nil	1 L on *A. falcataria* 2 L on *P. granatum*
Total		453		53	6	0	11	0	11 on *T. indica* 7 on *P. granatum* 1 on *A. falcataria*

trees, eg. *A. falcataria, D. regia* and *Eucalyptus tereticornis;* (2) heavy infestation of isolated trees leaving other trees of the same species in the vicinity unaffected, eg. *Canna indica, Emblica officinalis, Punica granatum, Syzygium cumini, Tamarindus indica* and *Trema orientalis;* and (3) sparse infestation, eg. other trees listed in Table 3. Infestation of *E. tereticornis* needs special mention. It was recorded for the first time in August 1984 in small-scale plantations within the SO_2–polluted premises of the Indian Aluminium Company at Kalamasseri near Cochin. A large population of the bagworm had been built up earlier at Kalamasseri, an industrial belt, where there are extensive avenue plantings of *D. regia.* Infestation of eucalyptus has not been observed elsewhere although there are extensive eucalypt plantations within the forest area. The hosts listed in Table 4 are those on which natural infestation has been found. In addition, low level feeding damage was found on some plants in the understorey of the infested *P. falcataria* plantation. These included *Acacia intsia, Clerodendrum viscosum, Manihot esculenta, Ochlandra travancorica, Schleichera oleosa* and several grasses.

In tests of host acceptability and preferences, the highest survival was obtained on *Tamarindus indica,* followed by *Punica granatum* and *A. falcataria* (Table 5). However, even on *T. indica,* the survival percentage was very low. Much of the mortality was apparently due to wandering of larvae out of the plants and escape from the cage. No establishment occurred on *Delonix regia* and *Syzygium aqueum* on which natural infestations were recorded (Table 4). The unacceptability of *Delonix* was particularly surprising since the larvae in trials 1 and 2 originated from parents that developed on *Delonix.*

DISCUSSION

This study has shown that the bagworm, *P. plagiophleps,* until recently an unimportant insect associated with the tamarind tree, has emerged over the last 10 years as a serious pest of new forest plantings of *P. falcataria.* In a 20 ha plantation, repeated defoliation over about two and a half years caused death or severe damage to about 40 per cent of the trees (Table 3). However, outbreaks occurred only in some plantations and they were not persistent. The insect is polyphagous and over a few years adapted to avenue plantings of *D. regia* in which outbreaks have now become almost regular. Its host relationships are complex and much remains to be learnt about the environmental and intrinsic biological factors which influence its population dynamics to bring about outbreaks. Although more extensive and quantitative data are clearly necessary, it is instructive to highlight the insight gained from this limited study, as a basis for future investigations.

One of the major characteristics of *P. plagiophleps* infestation is that population outbreaks occur only in some plant species although it has a wide host range covering diverse families. Even on the same host species, outbreaks occur only in some trees or plantations. These, together with the chronological development of outbreaks in *P. falcataria* and *D. regia* suggest the formation of host races. However, in our experiments with five plant species using the progeny of insects collected from naturally infested *D. regia,* the larvae failed to establish on *D. regia* saplings. This suggests an alternative hypothesis that successful infestation leading to large population increase is dependent on host stress. Host stress may be brought about by adverse site factors or by mass attack by a large population of the pest

itself and there could be wide variability in intrinsic host defences among different plant species against the bagworm. Infestation of *E. tereticornis* exclusively in the SO_2 polluted environment also favour the host stress hypothesis. Apparently, the roadside trees of *D. regia* are not growing in ideal sites. Increasing evidence has now accumulated to indicate that site factors play a decisive role in the population dynamics of many forest insects (BERRYMAN, 1986), if not of all, and this has led to the hope that forest insect outbreaks can be prevented by site amelioration (BERRYMAN & BALTENSWEILER, 1981). Further investigations are necessary to determine the relationship between bagworm outbreaks and site factors in *P. falcataria* plantations. Both extensive data on occurrence of outbreaks in plantations of various site qualities and intensive quantitative studies on population dynamics are necessary to understand the causation of outbreaks. With the exception of *Thyridopteryx ephemeraeformis* in North America (SHEPPARD, 1975; HORN & SHEPPARD, 1979), few studies have been attempted on the population dynamics of bagworms, a group of insects with peculiar biological attributes and containing many important pests of tree crops in the world (MATHEW & NAIR, 1984).

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OVICIDAL ACTION OF CERTAIN CHITIN SYNTHESIS INHIBITORS IN MOSQUITOES

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Ovicidal action and delayed effects of three chitin synthesis inhibitors, diflubenzuron, penfluron and Bay SIR 8514 were studied in mosquitoes, *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* **and** *An. culicifacies*. **Penfluron was found to be most effective as an ovicide against the eggs of** *Ae. aegypti* **and** *An. culicifacies* **while diflubenzuron proved to be better than other compounds against** *Cx. quinquefasciatus* **and** *An. stephensi*. **Freshly laid eggs were more susceptible to the chemicals as compared to older eggs. Treated eggs showed abnormal hatching. All the compounds at higher concentrations caused delayed effects such as increased larval mortality and very low adult emergence.**

(*Key words:* chitin synthesis inhibitors, anopheline mosquitoes, culicine mosquitoes, IC_{50}, ovicidal effect, larval mortality, pupal mortality)

INTRODUCTION

Among the insect growth regulating compounds, a few chitin synthesis inhibitors are known to be very effective against the larval stadia of many species of mosquitoes (GEORGHIOU & LIN, 1975). These compounds are environmentally safe having least impact on aquatic ecosystems (MIURA & TAKAHASHI, 1974, 1975). Though ovicidal effect of certain chitin synthesis inhibitors has been indicated against certain culicine mosquitoes (MIURA *et al.*, 1976; MIURA & TAKAHASHI, 1978) their possible delayed effects of ovicidal treatment in larval and adult stadia are not known. This factor is important in the deployment of these compounds in mosquito abatement programmes. Hence the objective of the present investigation was to ascertain the ovicidal activity and the delayed effects of three chitin synthesis inhibitors viz., diflubenzuron, penfluron and Bay SIR 8514 against culicine and anopheline mosquitoes such as *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* and *An. culicifacies*.

MATERIALS AND METHODS

Mosquito eggs were drawn from laboratory colonies of *Cx. quinquefasciatus*, *Ae. aegypti*, *An. stephensi* and *An. culicifacies* raised from blood-fed females collected from fields in Delhi during 1979 and since then maintained at 27 ± 2°C, 85 ± 5% RH and provided with 14 h of artificial daylight using an automatic electronic dimmer (BAKSHI *et al.*, 1982; CHITRA & PILLAI, 1984). The compounds, diflubenzuron and penfluron (90% pure) were supplied by Dr. A. B. Borkovec, USDA, Beltsville, U. S. A. Bay SIR 8514 (technical grade) was obtained from Bayer (India) Limited, India.

Freshly laid mosquito eggs of two age groups, viz., 0–6 h old and 0–18 h old were used for the treatments. They were exposed for 6 to 8 serial dilutions of the compounds.

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Stock solutions of the compounds were prepared in acetone and the desired dilutions were made by adding 1 ml of the appropriately diluted solution in acetone to 249 ml of dechlorinated water in a 16 oz jar. In each treatment approximately 100 eggs collected on a filter paper were immersed in the treated water (ANONYMOUS, 1981). Eggs of the age group 0–6 h were continuously exposed for 18 h while that of 0–18 h were exposed for 6 h and 18 h separately. After the exposure period, the eggs were thoroughly rinsed with water and left in enamel bowls containing water to hatch. Parallel control experiments were performed using the same number of eggs in untreated water. The number of eggs hatched was scored and the per cent hatchability was calculated using the control data. IC_{50} values (concentration which causes 50% inhibition of egg hatch) were computed using log dosage and per cent hatchability (ANONYMOUS, 1981).

In order to study the delayed effects of the treatments at egg stage the larvae hatched out from the treated eggs were separately reared till adult stage. Mortality at larval stages, pupae and adults were recorded every 24 h. Abnormalities in egg hatch, larval and pupal moults and adult emergence were examined and scored separately. Mortality at larval stages, and at pupal and adult stages were calculated and corrected for controls by ABBOTT's (1925) formula.

RESULTS AND DISCUSSION

Treatment of 0–6 h old eggs of *Cx. quinquefasciatus* for 18 h showed that 0.0075 ppm of diflubenzuron could inhibit 50% hatchability of the eggs while the older eggs (0–18 h old) required 5 times and 8 times more diflubenzuron to produce the same effect when exposed for 18 h and 6 h respectively (Table 1). Diflubenzuron was more effective than penfluron while Bay SIR was the least effective among the three compounds.

On the contrary, *Ae. aegypti* eggs were highly susceptible to penfluron when 0–6 h old eggs were treated as diflubenzuron was 2 times and Bay SIR 5 times less effective than penfluron (Table 1). Shorter exposure of 6 h was less effective than 18 h exposure in 0–18 h old eggs. *An. stephensi* eggs were highly susceptible to diflubenzuron, being 1.5 times and 5 times more active than penfluron and Bay SIR respectively (Table 1). The eggs of *An. culicifacies* were slightly more tolerant than that of *An. stephensi*. Penfluron was found to be 12 times more toxic than diflubenzuron and 2.5 times more than Bay SIR when 0–6 h old eggs of *An. culicifacies* were exposed to 18 h (Table 1).

It is evident from the results that though the eggs of all the species of mosquitoes tested were susceptible to chitin synthesis inhibitors, the ovicidal activity was more pronounced in the eggs of anophelines than that of culicines. Also, diflubenzuron was found to be most effective against *Cx. quinquefasciatus* and *An. stephensi* while penfluron was most potent against *Ae. aegypti* and *An. culicifacies* (Table 1). Diflubenzuron as a potent ovicide was first reported by ASCHER & NEMNY (1974) in *Spodoptera littoralis*. MIURA *et al.* (1976) and MIURA & TAKAHASHI (1978) demonstrated the ovicidal action of very low concentrations of diflubenzuron and Bay SIR in *Cx. quinquefasciatus*, *Cx. tarsalis* and *Ae. taeniorhynchus*.

The present data indicate that the age of eggs and the duration of treatments were two important factors which determined the effects of these chemicals; freshly laid eggs of all the species were more susceptible than the older eggs (Table 1). Similar findings were reported by MIURA *et al* (1976)

TABLE 1. Ovicidal effect of diflubenzuron, penfluron and Bay SIR 8514 expressed as IC_{80} when different species of mosquitoes were treated as eggs of 2 age groups for different durations.

Mosquito species	Compound	Age of eggs (in h)	Duration of treatment (in h)	IC_{80} (in ppm)	Heterogenity (Chisquare)
Cx. quinquefasciatus	Diflubenzuron	0–6	18	0.0075	0.9
		0–18	6	0.059	1.6
		0–18	18	0.040	9.6
	Penfluron	0–6	18	0.101	37.1
		0–18	6	0.066	2.9
		0–18	18	0.097	4.0
	Bay SIR 8514	0–6	18	0.939	6.3
		0–18	6	4.183	30.1
		0–18	18	4.390	56.2
Ae. aegypti	Diflubenzuron	0–6	18	0.011	1.8
		0–18	6	0.049	25.9
		0–18	18	0.045	6.5
	Penfluron	0–6	18	0.006	4.5
		0–18	6	0.012	22.0
		0–18	18	0.007	19.1
	Bay SIR 8514	0–6	18	0.030	26.7
		0–18	6	1.000	79.9
		0–18	18	0.024	51.1
An. stephensi	Diflubenzuton	0–6	18	0.003	2.6
		0–18	6	0.010	51.9
		0–18	18	0.004	1.9
	Penfluron	0–6	18	0.005	6.1
		0–18	6	0.031	7.5
		0–18	18	0.003	5.9
	Bay SIR 8514	0–6	18	0.025	0.7
		0–18	6	8.207	45.2
		0–18	18	0.005	37.7
An. culicifacies	Diflubenzuron	0–6	18	0.048	12.4
		0–18	6	0.196	4.4
		0–18	18	0.028	3.8
	Penfluron	0–6	18	0.004	3.4
		0–18	6	0.030	3.9
		0–18	18	0.016	0.1
	Bay SIR 8514	0–6	18	0.010	3.6
		0–18	6	0.550	6.5
		0–18	18	0.008	3.9

and MIURA & TAKAHASHI (1978) in culicine mosquitoes.

It was observed that the treated eggs contained developed embryos but the eclosion of the egg was either partial or incomplete. Also the test compounds retarded embryonic growth and delayed egg hatch by 12–24 h as compared to the normal eggs as reported by MIURA *et al.* (1976). Total inhibition of egg eclosion was evident only when exposed to higher concentrations of the compounds.

When mosquito eggs treated with higher concentrations of test compounds were reared upto adults, larval mortality and pupal mortality correspondingly increased (Table 2). Larval mortality was seen at the time of ecdysis in different instars while pupal mortality was noticed at larval-pupal moults or pupal-adult emergence (Table 2). Both diflubenzuron and penfluron were very effective in causing such delayed effects. Among different species, anophelines seemed to be slightly more susceptible than culicines in overall larval and pupal mortality.

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TABLE 2. Concentration (in ppm) of IGR compounds required in ovicidal treatment to produce delayed 100 per cent mortalities at larval and pupal stages of larvae hatched out from the treated eggs.

Mosquito species	0–6 h old eggs exposed for 18 h			0–18 h old eggs exposed for 6 h			0–18 h old eggs exposed for 18 h		
	DFB	PF	Bay SIR	DFB	PF	Bay SIR	DFB	PF	Bay SIR
Cx. quinque-fasciatus									
Larval stage	0.016	0.1	5.0	0.1	1.0	10.0	0.1	1.0	10.0
Pupal "	0.008	0.1	1.0	0.1	0.1	10.0	0.032	0.1	5.0
Ae. aegypti									
Larval stage	0.016	0.016	5.0	0.1	0.032	10.0	0.1	0.032	10.0
Pupal "	0.016	0.016	1.0	0.1	0.032	10.0	0.032	0.016	5.0
An. stephensi									
Larval stage	0.016	0.016	1.0	0.1	0.032	10.0	0.032	0.016	5.0
Pupal "	0.016	0.008	0.016	0.1	0.016	10.0	0.016	0.008	1.0
An. culicifacies									
Larval stage	0.1	0.1	0.1	1.0	1.0	5.0	1.0	0.1	5.0
Pupal "	0.032	0.016	0.1	1.0	0.1	1.0	0.032	0.016	1.0

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LONGEVITY AND ITS RELEVANCE TO FECUNDITY IN *ANTROCEPHALUS HAKONENSIS* (HYMENOPTERA: CHALCIDIDAE), A PUPAL PARASITOID OF *OPISINA ARENOSELLA* (LEPIDOPTERA: XYLORICTIDAE)

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The relationsip between longevity and fecundity of *Antroccphalus hakonensis* is discussed. Females lived one-fifth longer than the males. The different food items, viz., dilute honey, glucose and sucrose solutions produced more or less the same effect on longevity. The maximum number of eggs laid and the maximum progeny production per day is recorded to be six. On an average, a fertilised female laid 62-95 eggs during its life-time. A single female parasitized 5 pupae within 2 hours. Sex ratio is highly female biased. There is a significant positive correlation between longevity and fecundity.

(*Key words* : longevity, fecundity, sex-ratio, *Antrocephalus hakonensis*, *Opisina arenosella*)

INTRODUCTION

Antrocephalus hakonensis (Ashmead) is one of the pupal parasitoids of *Opisina arenosella* Walker, the black-headed caterpillar pest of coconut. MOHAMED *et al.* (1982) conducted preliminary studies on some aspects of its reproductive biology and life history. More detailed investigations on this chalcid species were undertaken by the present authors. This paper provides information on the reproductive potential and life expectancy of *A. hakonensis* in an attempt to analyse its efficacy as an effective tool for the biological control of *O. arenosella*.

MATERIALS AND METHODS

To study the fecundity of each female, fresh as well as 1- to 2- day old pupae of *O. arenosella* reared in the laboratory were provided regularly to the mated and honey fed females of *Antrocephalus hakonensis*. Specimen tubes (2.5 × 10 cm) stoppered with cotton plugs were used for this purpose. The studies were carried out in the prevailing laboratory conditions (Temperature: 28.03 ± 1.28° C and Relative Humidity: 56 ± 7.47).

Data on longevity were analysed using two way analysis of variance. All the data gathered on the egg laying females were pooled and statistically analysed to ascertain the maximum number of eggs laid by a female per day and to determine the influence of the pupal size as well as the age of the parasitoids on the sex-ratio of the progeny. The data on fecundity and longevity were compared to explore the possibility of the existence of any positive correlation between the two.

RESULTS

Fecundity:

The preoviposition period in *A. hakonensis* lasted for 1–5 days (Mean 2.15 days: n=20). The female, on an average, laid 2.3 eggs/day, and the maximum number of eggs laid in the course of a day is 6 (Table 1). The

TABLE 1. Frequency distribution of the number of eggs laid/day/female (a).

No. of eggs laid/day/♀	0	1	2	3	4	5	6
Frequency of occurrence	4	11	17	14	14	13	11

(a) Data from four regularly egg laying females.

TABLE 2. Progeny production per day by individual *Anttrocephalus hakonensis* females (b).

No. of progeny/day/♀	0	1	2	3	4	5	6
Frequency of occurrence	31	40	35	21	12	4	1

(b) Data from 4 regularly egg laying females.

maximum number of eggs laid at a stretch is also 6. An average duration of 7.87 minutes was required for a successful oviposition. The parasitoids spent more time on large and naked pupae, compared to medium sized pupae, enclosed in a cocoon of silk and frass. The maximum number of eggs laid by a female during its life span was recorded as 94, spread out for a period of 32 days. The rate of egg laying is represented in Fig. 1.

The incidence of superparasitism was noted by dissecting out a batch of 5–6 pupae exposed to a single female parasitoid for a period of 24 hours. One or two pupae in such cases, contained 2 eggs (rarely 3 also) while the rest was either with a single egg or devoid of eggs. When the pupae were exposed for two hours, no case of superparasitism was observed to occur.

The maximum number of progeny produced by a single female is 98 (30 males and 68 females) in the course of 59 days. A second one produced 62 numbers in 30 days and a third one 51 in 36 days. Usually, 1 to 2 progeny are produced per day with a maximum of 6 (Table 2). Oviposition is at its peak during the second and third

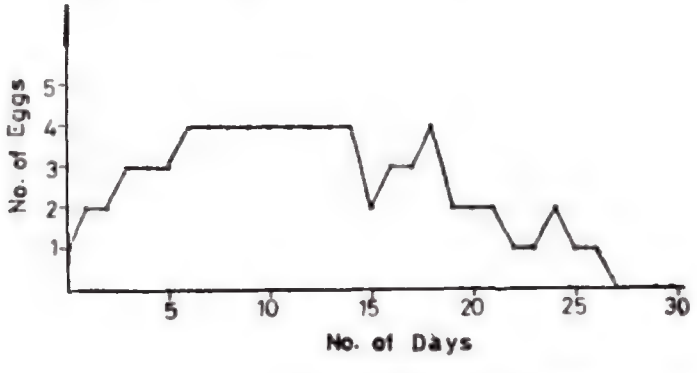

Fig. 1. Rate of egg laying by *Antrocephalus hakonensis*.

week after emergence, which then declines gradually. The percentage emergence of *A. hakonensis* was lower from the pupae exposed to the parasitoids for 24 hours, as compared to those exposed for 2 hours. In the case of the hosts, the pupal mortality was also higher in the former case when compared to the latter where more number of adults emerged.

All the 5 pupae supplied were found to be parasitized within a period of two hours. The average time taken by the parasitoid to parasitize the same number of pupae when supplied in tandem was observed to be 39.36 minutes.

Sex-ratio:

The sex-ratio was highly female biased in the laboratory reared parasitoids. Data from field study also support this. Out of a total of 248 progeny produced by 4 females, 74 were males and 174 were females. Thus

TABLE 3. Number of male or female progeny produced from small or large *Opisina arenosella* pupae by *A. hakonensis*.

Size of host pupae	Age of the parasitoid				Total Emergence	
	1—15 days		16—30 days			
	♂	♀	♂	♀	♂	♀
Large	10	50	12	48	22	98
Small	19	16	28	10	47	26

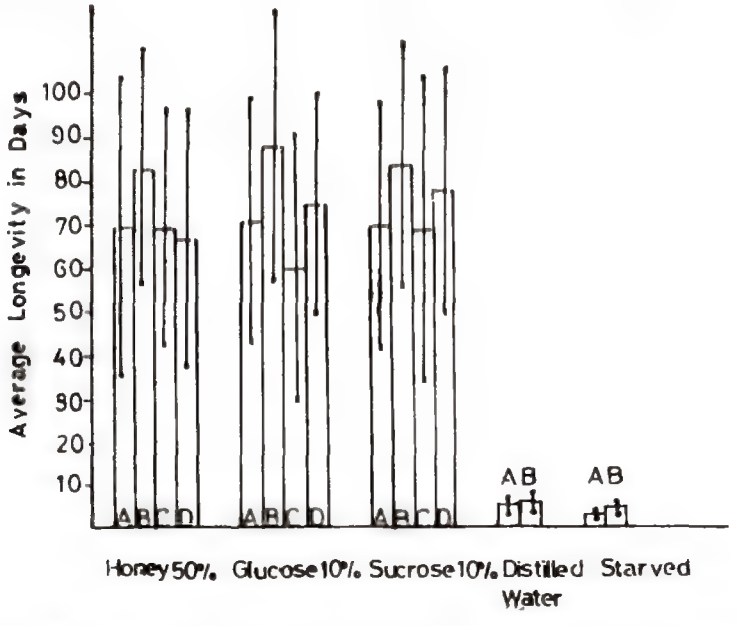

Fig. 2. Mean longevity of *Antrocephalus hakonensis* on five different food regimes.
A. Unmated Male C. Mated Male
B. Unmated Female D. Mated Female

the average sex-ratio is 42.53 males for 100 females.

The age of the ovipositing parasitoid female as well as the size of host pupae have a profound influence on the sex-ratio of the progeny (Table 3). The data clearly shows that the male to female ratio of the progeny that emerged during the III and IV weeks, from both the large and small groups of pupae was on an increase. Proportion of the males was higher in the progeny produced from smaller pupae compared to those produced from the larger ones.

Longevity:

The data on longevity is represented in the form of a bar diagram (Fig. 2). The range was found to be very wide, e.g., in the case of unmated females fed on dilute honey, it was found to be between 4 and 149 days. Females lived longer when compared to males. Individuals fed on distilled water lived a little longer than the startved ones.

The following results were obtained when the data on longevity were analysed using a two way ANOVA. No significant interaction

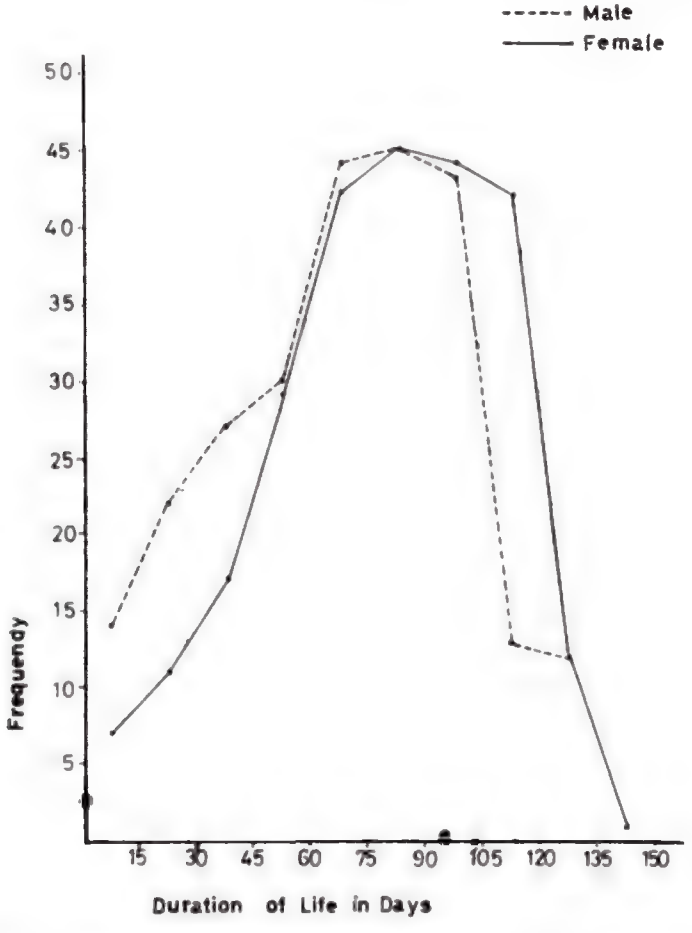

Figure 3. Frequency polygon showing the distribution of 250 males and 250 females according to their duration of life in days.

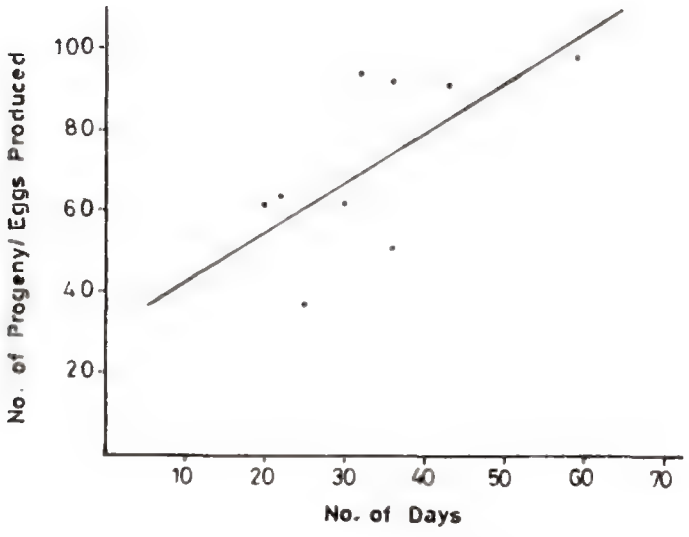

Fig. 4. Correlation between longevity and fecundity of *Antrocephalus hakonensis.*

between mating status (mated or unmated) and treatments was observed in the case of males. That means the treatments have same effects on mated and unmated individuals. It is also found that there is no significant difference at 5% level between the mean longevities of mated and unmated individuals. Similarly there is no marked difference between the effects of various treatments, viz., honey, glucose and sucrose.

In the case of females also there is no interaction between mating status and treatments. However, the analysis revealed a significant difference between the mean longevities of mated and unmated females at 5% level. But, there is no significant difference between the different treatments.

As there was no difference between the treatments, all the data were grouped together to find out the frequency distribution of the life span of the males and females. The life span of 250 males thus ranged between 2-135 days (Mean 68.75, S.D. 30.848) and that of the females between 4–149 days (Mean 79.15, S. D. 29.38). It is diagramatically represented in Fig. 3.

Correlation between longevity and fecundity:

A remarkable positive correlation is observed between longevity and fecundity. From the analysis it is found that the factors are correlated at 0.02 level ($r = 0.65$). In the case of regularly egg-laying females, it is possible to predict with a great degree of accuracy, the fecundity for a given longevity (Fig. 4). Individuals that lived longer deposited more number of eggs. But the life span of regularly egg-laying females was found to be considerably reduced, varying from 20–30 days only.

DISCUSSION

BARBOSA & FRONGILLO, JR. (1979) observed that the maximum progeny production by *Brachymeria intermedia* per day is 6. In the case of *Antrocephalus hakonensis,* the maximum number of eggs laid per day is also 6, and coincides with the structure of its reproductive system, which consists of two ovaries with three ovarioles each.

The excess handling time taken by the parasitoid during oviposition in the naked pupae of the host is due to its vigorous wriggling movements. Pupae in cocoons of silk and frass are readily oviposited. So, while culturing much time can be saved by providing such pupae. The parasitoid took only 30 minutes to 1 hour to parasitize 5 pupae when provided in tandem. This, together with the fact that no superparasitization occurred when the same number of pupae were exposed to the parasitoid for 2 hours, provides sufficient clue to the optimal period of exposure as 2 hours. PATANA (1979) observed that *Brachymeria ovata* could parasitize 5 pupae of *Heliothis virescens* during a period of 2 hours. Pupal mortality was also very low when exposed only for 2 hours. PILLAI & NAIR (1982) suggested that the parasitized pupae must be removed immediately after oviposition to avoid superparasitism.

The egg laying capacity of *A. hakonensis* is appreciable in comparison with the other two chalcid parasitoids of *Opisina arenosella;* viz., *Brachymeria lasus* which laid 131 eggs in 43 days (NARENDRAN & JOSEPH, 1976) and *B. nephantidis* that laid only 15–23 eggs during its life time (SATPATHY & RAO, 1972). Although there is a hike in oviposition in the second and third weeks after emergence, the general pattern shown by the parasitoid is a moderate egg laying activity throughout its life time. This makes the parasitoid unfit for inundative release when the pest outbreak is severe in a localised area, but rather makes it suitable when it is spread over a wide area. JOY & JOSEPH (1977) have pointed out comparable disadvantages of *Brachymeria* spp. parasitic on *Opisina arenosella.*

The average fecundity shown by the parasitoid does not tally with the average progeny production in the laboratory conditions. A failure for the full realisation of the latter may be due to the host mortality. Sterile probing excessive stinging or some other unknown factors may be the cause of host mortality in the laboratory. Superparasitization rarely becomes a cause of pupal mortality in the case of solitary pupal parasitoids. ARTHUR (1958) reported that *Spilochalcis side* laid 1–4 eggs in a single host pupa but one adult parasitoid successfully emerged out of it. However, superparasitization results in wastage of parasitoid eggs. The superparasitizing tendency often observed in *Antrocephalus hakonensis* when the pupae are exposed to it for 24 hours is avoided by exposing the pupae to the parasitoid only for 2 hours.

The highly female biased sex-ratio is advantageous in maintaining a mass culture of the parasitoid. From Table 3 it is clear that the male to female sex-ratio of the progeny is gradually increased as the mother becomes older. BARBOSA & FRONGILLO, JR. (1979) also indicated an increasing proportion of the males as the maternal age increases, in the case of *Brachymeria intermedia* (Nees). MOHAMED & COPPEL (1986) concluded that the sex-ratio regulation in *Brachymeria intermedia* female is a species specific function and variables such as host size, host density, and intraspecific competition played no role in it. In *Antrocephalus hakonensis* the size of the host pupa has a substantial influence on its sex-ratio. Production of males is higher in the progeny produced from smaller pupae in both the younger and older females (Table 3). A definite conclusion on the exact cause influencing the sex-ratio cannot be derived without investigating further on the role of host density and intraspecific competition in this species.

Longevity of *Antrocephalus hakonensis* is much higher compared to *Brachymeria*

lasus and *B. nephantidis*. Longevity of the males was 15–20% less than those of the females. PATANA (1979) reported that in *Brachymeria ovata* the females lived one-third longer than the males. When different food items viz., honey, glucose and sucrose, were provided, it gave more or less the same results; however, honey was preferred over the others as it gives better results with regard to the reproductive efficiency of the parasitoid.

The higher longevity in the case of non-laying females may be due to their saving on energy resource. The great strain on the part of the regularly egg laying female, together with the extra demands on her stored nutrients for the continuous production of eggs, may account for the reduced life span in this case.

The nearly perfect positive correlation between longevity and fecundity can have a bearing on the field release of the parasitoid. When the environmental setting is congenial for the maximum survival of the females, best reproductive performance can be expected in the field.

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PHOSPHOLIPIDS DURING THE DEVELOPMENT OF PHASEPHENISM IN *LIPAPHIS ERYSIMI* (KALT.) (HEMIPTERA : APHIDIDAE)

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Total lipids and phospholipids of the mustard aphid *Lipaphis erysimi* were studied quantitatively and qualitatively during the development of phenic phases on fresh weight basis. The first instar contained the highest lipid content and third instar alatae the least. But the adult alatae had a relatively higher lipid content than adult apterae. On both fresh weight and total lipid basis, the phospholipid content was more throughout the development of apterae phase as compared to alatae. The qualitative study of phospholipids revealed the presence of cardiolipin, phosphatidyl ethanolamine (PE), phosphatidylcholine (PC), phosphatidylserine (PS), phosphatidylinositol (PI) and sphingomyelin (Spm) which were stage specific.

(*Key words*: phospholipids, *Lipaphis erysimi*, phasephenism development)

INTRODUCTION

The appearance of phasephenism has been correlated with functions that are to be performed by a particular phase during adulthood (HARDIE & LEES, 1985). In the mustard aphid *Lipaphis erysimi*, the alatae phase is associated with the migration and host selection and the progeny production is associated with the apterae phase. However, both the functions require lipids (FULTON & ROMNEY, 1940) with specific quantitative and qualitative variations. RUP & BHATIA (1988) have correlated the total lipid content and changes in neutral lipids during the development of polyphenic forms of *L. erysimi*. Since no report on changes in phospholipid content was encountered in literature, the present work was undertaken.

MATERIALS AND METHODS

Field collected females of *L. erysimi* were released for 6 h on radish (*Raphanus sativus* L.), grown in 1 kg capacity pots. The plants were enclosed in glass chimneys having wider end covered with muslin. The nymphs required for first, second, third, fourth instars and adults were collected after 24, 75, 130, 188 and 240 h respectively. Alatae and apterae in the third and fourth instars were differentiated on the basis of presence or absence of wing buds.

The method of FOLCH *et al.* (1957) was used for the extraction of total lipids from 100 mg fresh weight of each stage and adults. Phospholipids were estimated on the basis of phosphorus content by using the methods of AMES (1960) and AMES & DUBIN (1960).

Qualitative study of total lipids was performed with the help of thin layer chromatography on silica gel G. The eluent system of LEPAGE (1964) was used for the separation of lipids. The separated spots were developed with iodine vapours and by charring with sulphuric acid. Phospholipids were identified by using specific stains which were: phosphate stain

of DITTMER & LESTER (1964) as modified by VASKOVSKY & KOSTETSKY (1968) for total phospholipids, ninhydrin stain of SCHLEMMER (1961) for amino phosphatides; Dragendorff's stain of SCHLEMMER (1961) for choline containing phospholipids and sodium-metaperiodate-benzidine solution of CIFONELL & SMITH (1954) for sugar polyalcohols.

RESULTS

The quantitative estimation of total lipids and phospholipids showed a specific pattern during the development of polyphenic forms of *L. erysimi*. The first instar contained maximum amount of total lipids (44.6 per cent / fresh weight) which decreased suddenly in second instar to 19.5 per cent and the decrease continued gradually in apterous forms. There was a relatively more decrease in third instar alatae as compared to apterae followed by an increase and the level reached 21.5 per cent in adults. Finally, the amount was more in adult alatae than in adult apterae (Fig. 1).

The phospholipid content was minimum on the total lipid basis in first instar and maximum in second instar. It stayed approximately at the same plateau during the development of apterae but in alatae it decreased to a lower level with slight increase in adults (Fig. 2).

Qualitatively, cardiolipin, phosphatidylcholine (PC), phosphatidylserine (PS) phosphatidylinositol (PI), phosphatidylethanolamine (PE) and sphingomyelin (Spm) were identified in *L. erysimi*. In the second instar, the total number of phospholipid types increased from two to

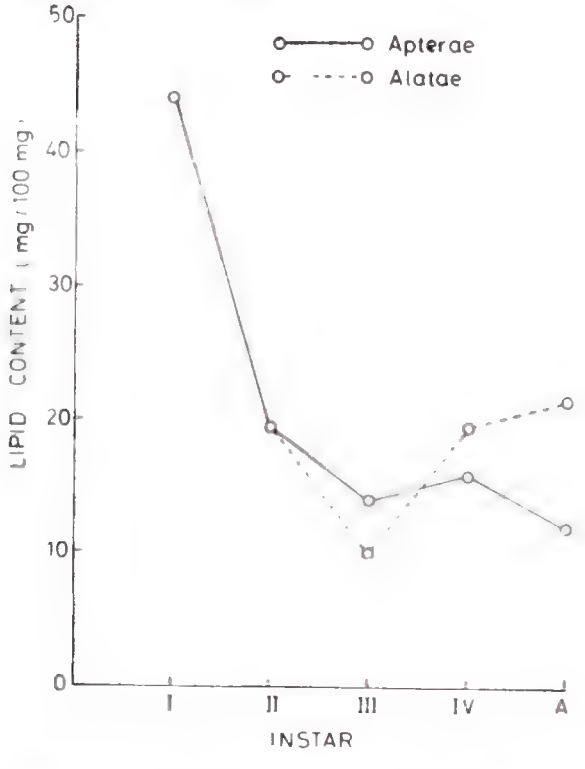

Fig. 1 Total lipid pattern of different developmental stages of *L. erysimi*.

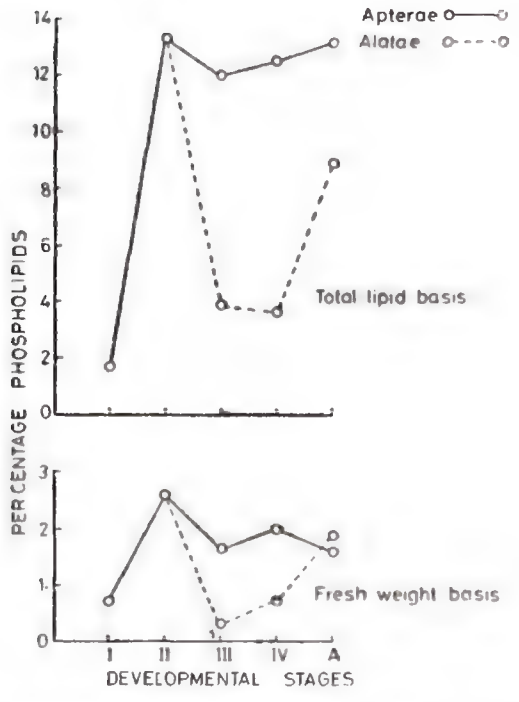

Fig. 2 Percentage phospholipids of various instars of *L. erysimi*.

four where PC of first instar disappeared and the three phospholipids (PS, PI and Spm) appeared in addition to cardiolipin. The pattern remained the same in third instar apterae. The additional PE and PC appeared in fourth instar and adult apterae taking the number to six. There were only cardiolipin and Spm in the third and fourth instar alatae, thereby reducing the number from four in second instar to two in these stages. But all the six phospholipids, which were recorded in the apterae adults, were also present in alatae adults (Fig. 3).

DISCUSSION

The high lipid content in the first instar could be a contribution from the mother aphid. Then in this instar, the balance between the conversion of food into storage lipids was in negative. As a result, in the second instar, the lipid content decreased considerably. BASALINGAPPA *et al.* (1982) had also reported a similar trend in larvae of *Parasa lepida* where the second instar had the minimum amount of lipids. The accumulation of lipids started after the third instar depending upon the future needs of the insects. A relatively more decrease in total lipids in the third instar alatae could be due to the utilization of food intake into the wing differentiation than being getting converted into storage lipids. The lipid storage had started in fourth instar and the rate was more in alatae which could be for meeting the fuel needs for flight in adults. NAWANZE *et al.* (1976) have similarly reported almost a double increase in the total lipids of flight forms of *Callosobruchus maculatus* as compared to normal sexuals. Moreover, BEENAKKERS *et al.* (1981) have listed the

lipids among the major source of fuel in flight in most of the insects.

A wide range in the ratio of phospholipids to total lipids of insects has been reported by FAST (1964). He has reported that the phospholipids constituted 0.25 per cent in *Ergates faber* and the amount was 39.6 per cent in *Drosophila melanogaster*. The highest range was given by LEE *et al.* (1975) in *Gerris remigis* where phospholipids constituted 49 per cent of total lipids. But we have found that the phospholipids content in total lipids even varied during the development of *L. erysimi*. It was minimum in the first instar and increased in the second instar. The same ratio was more or less maintained in the development of the apterae. However, in alatae phase, the phospholipid content again decreased suddenly in third and fourth instars, thereby indicating the involvement of phospholipids in wing differentiation. The relatively low levels of phospholipids in adult alatae compared with apterae could be due to their low reproductive potential. DUTKOWSKI & ZIAJKA (1970) have also reported sex related quantitative changes during the development of *Galleria mellonella*, where in male the phospholipids varied from 3–5 per cent and in female from 2–7 per cent. Function related changes in the phospholipids during development of *Athalia proxima* and *Dysdercus cingulatus* have also been reported by SIDHU *et al.* (1984) and ZAIDI & ANSARI (1985) respectively.

In all, qualitatively, six phospholipids (cardiolipin, PC, PS, PI, PE and Spm) were identified by TLC during the development of phenic phases and adults.

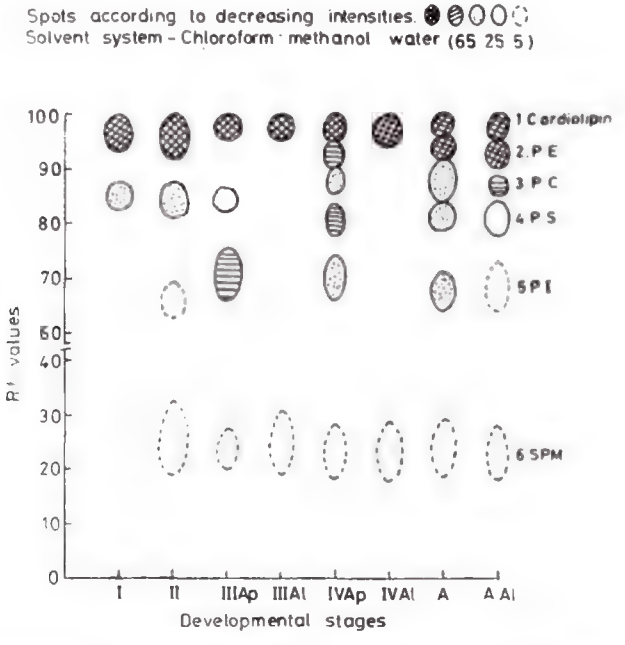

Fig. 3 Thin layer chromatogram of phospholipids of *L. erysimi*. Staining reagents used: Ninhydrin stain, Dragendorff's stain and sodium-metaperiodate benzidine solution. The spots identified were : (1) orange yellow, cardiolipin; (2) pink mauve; PE; (3) orange yellow, PC; (4) orange yellow, PS; (5) white on blue background; (6) orange yellow, Spm.

These were similar to the ones reported by FAST (1964) and RAO & AGARWAL (1970, 1971). However, there was a specificity for a particular phospholipid in specific developmental stage. There were only cardiolipins and PC in the first instar, probably a contribution from the mother. PC disappeared in the second instar but three additional phospholipids (PS, PI and Spm) made their appearance in the second instar. PE and PC appeared by the time the nymphs reached adult stage. In the nymphs of third and fourth instar alatae, there were only two classes of phospholipids indicating ultilization of special categories of lipids in the wing differentiation. The accumulation of PE and PC during third and fourth instar apterae and the reappearance of these in adult alatae confirmed the requirement of these for vitellogenesis and other reproduction related functions.

RAO & AGARWAL (1969) have reported a quantitative change in the different classes of phospholipids in the development of *Trogoderma granarium*. In larvae, PE was the major phospholipid whereas in adults, the PC and PE were the major phospholipids. They had further found that fourth and fifth instars had minimum classes of phospholipids (RAO & AGARWAL, 1971). However, KALLAPUR *et al.* (1982) did not find any qualitative differences in the different phases of *Schistocerca gregaria*. The phase specificity of the biochemical pool during development of *L. erysimi* has been illustrated in proteins, glycogen and trehalose by RUP & SOHAL (1989) and in some hydrolytic enzymes by RUP & KALRA (1989).

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STUDIES ON THE THORACIC MUSCLE TREHALASE OF THE WHITE GRUB ADULT, *HOLOTRICHIA SERRATA* FAB (COLEOPTERA : SCARABAEIDAE)

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The optimal pH, the optimal temperature and K_m of the enzyme trehalase of male and female thoracic muscles of *Holotrichia serrata* Fab. were determined. The optimal pH and optimal temperature for both male and female thoracic muscle trehalase was 6.4 and 40°C respectively. The K_m for female trehalase was 5.28×10^{-3} M and for male trehalase was 4.29×10^{-3} M. The half life for female trehalase at 50°C was 40 min. Thoracic muscle trehalse activity of the male was 2.58 times more than the feamle.

(*Key words:* white grub, *Holotrichia serrata*, thoracic muscles, trehalase characteristics)

INTRODUCTION

In Maharashtra, *Holotrichia serrata* Fab. has been recorded as a prominent species of white grub attacking roots of a variety of crops like sugarcane, jowar, maize, bajara, paddy, groundnut, tobacco, chillies, tomatoes and other vegetable crops (RAODEO *et al.*, 1974). Adults of this species have a peculiar habit in that they emerge from the soil at dusk after the first monsoon showers for the purpose of feeding, mating and selecting a suitable site for egg laying. After emergence, adults take to active flight of short range for about 10 to 15 min, then they alight on the branches of host plants for feeding and mating. At the time of flight, it is suspected that the adults of *H. serrata* depend very much on the energy derived from the oxidation of carbohydrate. Therefore investigation of the characteristics of thoracic muscle trehalase is of great interest.

Trehalase is the major blood carbo hydrate of insects and is hydrolysed to two glucose molecules by the enzyme trehalase (a, a'-trehalase 1-D-glucohydrolase, EC 3.2.1.28). Trehalase is one of the most important carbohydrolases in insects occurring in gut, flight muscles, fat bodies and labial glands. It is an important enzyme because it degrades trehalose to glucose for internal energy supply (WYATT, 1967). The activity of trehalase varies, according to the method of preparation, type of tissue used and the species source (ZABE & MC SHAN, 1959; SAITO, 1960; DUCHATEAU - BISSON *et al.*, 1963; DERR and RANDAHL, 1966; GILBY *et al.*, 1967). This enzyme has been extensively studied and substantially purified from several insects and non-insect sources (FRIEDMAN, 1960; FISHER & MC ALISDER, 1969) and many of its properties are known. But relatively very little information is available concerning white grub trehalase (COURTOIS *et al.*, 1962; ALLMANN & DUSPIVA, 1966; GUILLOUX *et al.*, 1971; MISHRA & SEN SHARMA, 1987). If one considers the apparent significance of trehalase in the energetics of insects, the investigation of trehalase in the thoracic muscle tissues

which are activiely involved in flight activities, might serve as an indicator of the relative importance of carbohydrate metabolism in this tissue during flight.

Therefore, the purpose of this work was to characterize the thoracic muscle trehalase of *Holotrichia serrata* and compare it with that from other insect species, including other white grub species.

MATERIALS AND METHODS

Adult male and female white grubs were caught in their natural habitat (after first monsoon showers on their host plants). They were maintained in the laboratory at $26 \pm 2°C$ on a diet of fresh tender leaves of babool and neem for a period of five days in plastic containers. Then the male and female individuals were sacrificed separately and their thoracic muscles were removed in chilled glass distilled water. These muscles were homogenized, using a chilled tissue grinder, in chilled glass distilled water in the ratio of 40 mg to 1 ml distilled water. Homogenates were centrifuged at 0°C for 15 min at 10,000 r p m. The supernatants were used in the assays.

The reaction mixture contained 0.5 ml enzyme extract, 1 ml of phosphate buffer of Sorenson and 1 ml of trehalose solution (0.5 %). In the control, the enzyme extract was preheated in a water bath maintained at 100°C for 10 min. Incubation was done at 40°C for 60 min unless otherwise stated. During incubation, the reaction mixture was shaken at 20 min intervals. The reaction activity was determined by measuring the amount of glucose formed with 3, 5 dinitrosalicylic reagent (DNS). The DNS reagent was prepared by a procedure similar to that of NOELTING & BERNFIELD (1948). After the termination of the reaction, 2.5 ml of DNS reagent and 2.5 ml of distilled water were added to the reaction mixture. The mixture was then heated for five minutes at 100°C in a water bath followed by immediate cooling in an ice bath. The absorbance was measured in a Bosch & Lomb Spectronic 20 spectrophotometer at 540 nm. Any reducing sugar present in the enzyme extract was offset by using the control as a blank to set the absorbance at zero. The standard curve was obtained from the direct reaction of glucose with DNS reagent, under conditions similar to those for the enzyme reaction. The trehalase activity was expressed as μg glucose/μg protein/h under the assay conditions. The protein concentration of the enzyme extract was determined according to the Lowry method (LOWRY *et al.*, 1951).

RESULTS

Effect of pH:

The optimal pH was determined by using 0.1 M buffers of appropriate pH: 4.6 to 5.2 acetate buffer; 5.8 to 8.00 phosphate buffer. The maximal activity of trehalase in both male and female occurred in the pH range 6 to 6.8, with an optimum pH at 6.4 (Fig.1). The pH value of haemolymph as determined with pH papers was 6.5 to 7.

Effect of temperature:

The effect of temperature on trehalase activity was studied at the following temperature : 20, 30, 40, 50 & 60°C. Fig. 2 shows that the maximal activity occurred at the temperature of 40°C.

Thermolability:

Eight tubes of 2 ml enzyme extracts of female muscles were used. One tube was stored at 5°C until needed and served as a control. The other seven tubes were

put in a water bath maintained at 50°C for varying periods from 5 to 90 minutes. After the treatment, tubes were cooled in ice cold water. The residual trehalase activity was determined as usual. The mean activity of control was taken as 100% activity. Figure 3 shows the percentage of inhibition of various treatments. The theoretical duration of high temperature treatment at 50°C for 50% loss of activity was found to be 40 min.

Effect of substrate concentrations:

The relationship between trehalose concentration and rates of hydrolysis is shown in Fig. 4. For the evaluation of K_m from the experimental data for velocities at various substrate concentrations Line Weaver-Burk's plot was employed using regression equation (Y=ax+b) Fig. 5. The K_m values for female muscles trehalase was 5.28×10^{-3} M and for male muscle trehalase was 4.29×10^{-3} M.

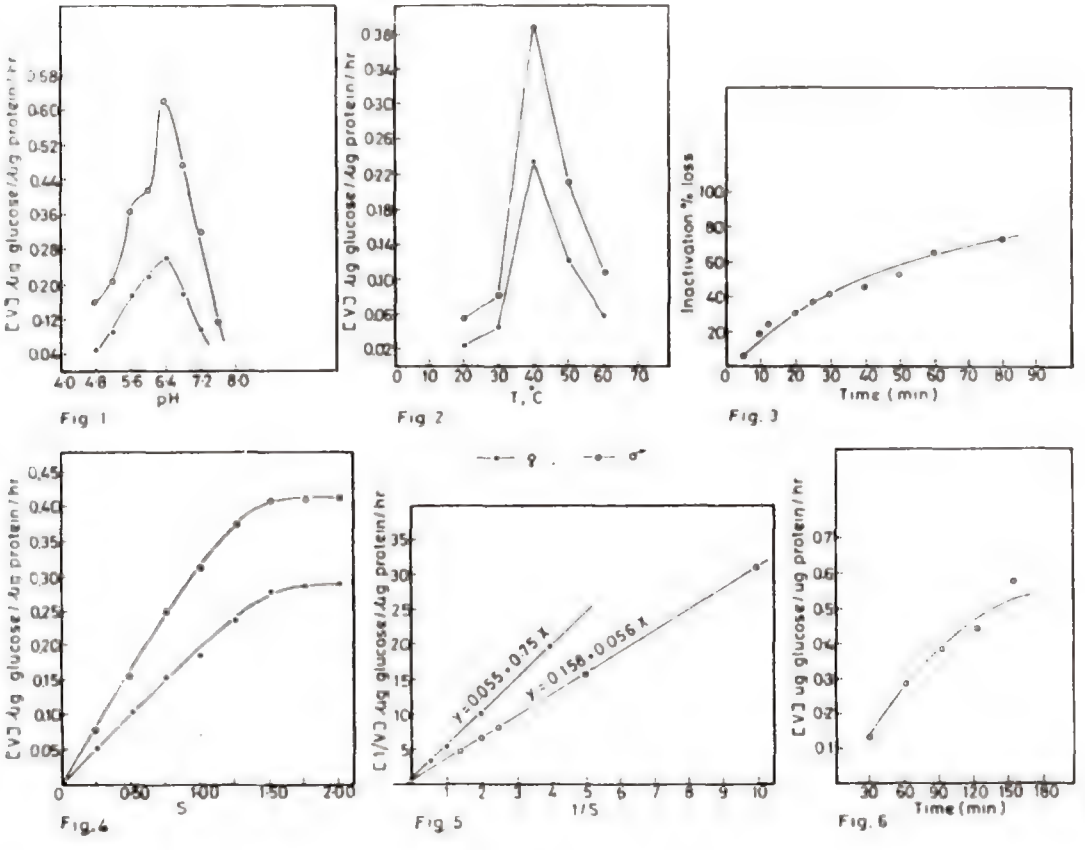

Fig. 1. The effect of pH on trehalase activity. Fig. 2. The effect of temperature on trehalase activity. Fig. 3. The relationship between inactivation of trehalase (%) and period (min) of heat treatment at 50° C. Fig. 4. The relationship between trehalose concentration and reaction velocity. S. trehalose concentration mg in assay mixture; V, reaction velocity (μg glucose/μg protein/h). Fig. 5. The Lineweaver-Burk plot of the relationship between reaction velocity and trehalose concentration. Fig. 6. The rate curve of trehalase activity. V, reaction velocity (μg glucose/μg protein/h) and time in minutes.

Effect of time:

A digestion period of 90 min for female muscle trehalase was found to fit within the linear part of enzymatic activity curve (Fig. 6).

Activities in different sexes:

Trehalase activity varies in different sexes. The trehalase of thoracic muscles of the male shows 2.58 times (0.6 μg glucose/μg protein/h) greater activity than those of the female (0.232 μg glucose/μg portein/h).

DISCUSSION

It is interesting that the optimal pH for the trehalase fell within the pH range of haemolymph. It indicates that the enzyme is well adapated to the conditions in the muscles, which are virtually bathed in the haemolymph. The optimal pH value is slightly higher than the optimal pH for trehalase of other insects (GILBY *et al.* 1967; CHANDURKAR & MEHROTRA, 1974; MODDER, 1981; WORM, 1981). The lowest pH (4.5) value was reported in *Phormia regina* and the enzyme was present in the midgut and blood of adult fly (FRIEDMANN, 1975). In the present study the optimal pH value (6.4) was in accordance with the results obtained in adult white grub, *Melolontha vulgaris* (6.5) by COURTOIS *et al.* (1962).

The trehalase activity increased linearly as the temperature was raised from 20 to 40°C. The optimal temperature for either sexes trehalase was 40°C. There was a significant drop in its activity when the temperature was further raised to 60°C. Similar higher optimal temperature values were reported for tropical species viz., *Hodotermis mosambicus* (RETIEF & HEWITT, 1973) and *V. nigricornis*. For the temperate species *Culex pipiens* the value of optimal temperature was comparatively less (GIEBEL & DOMNAS, 1976). These differences were thought to be due the difference in distribution of insect species.

So far very little study has been done on the thermal lability of trehalase. DAHLMAN (1971) made the most comprehensive study on the trehalase of the tobacco hornworm larvae *Manduca sexta*. In the grasshopper *Valanga irregularis* of Queensland (Australia), the gut trehalase had a half life period of 132 min at 60°C (MODDER, 1981). Apparently, this trehalase was much more heat stable than the thoracic muscle trehalase of the present insect *H. serrata*. This might be due to the fact that in Queensland, Australia, the summer can become extremely hot: the air temperature is usually in the upper 30°C and may go upto as high as 40°C. In Western Maharashtra, the air temperature seldom reaches 33° C during the month of June when the emergence of adult *H. serrata* takes place. Moreover, the emergence of adults *H. serrata* coincides with the onset of monsoon showers, which brings with it plenty of rainfall that brings down the air temperature. The trehalase of *M. sexta* was also quite heat stable since the residual activity remained over 80% after 60 min of heat treatment at 48°C (DHALMAN, 1971). On the other hand, the most thermal labile trehalase ever reported was that of *Drosophila melanogaster* as the half life period at 46°C was only 7.2 min. The present results on the thermal lability of trehalase of *H. serrata* are very much similar to those in *V. nigricornis*.

In the present studies K_m values obtained for male and female thoracic muscle trehalase were 4.29×10^{-3} M and 5.28×10^{-3} M respectively. Earlier workers reported different K_m values in different insect species viz., *M. sexta* 6.47×10^{-4} M (DAHLMAN, 1971). *Rhynchosiara americana*

6.7×10^{-4}, *Valanga nigricornis* 2.51×10^{-3} *Locusta migratoria* 4.14×10^{-3} (WORM, 1981), *Melanoplus differentialis* 5.1×10^{-3} (DERR & RANDALL, 1966), and *Hodotermis mossambicus* 9.7×10^{-3}M (RETIEF & HEWITT, 1973). Other white grub species, *Melolontha vulgaris*, smaller K_m values (7×10^{-4} M) (COURTOIS *et al.*, 1962) and in *Melolontha melolontha* also (6.14×10^{-4} M) (GUILLOUX *et al.*, 1978) were reported. Present values are 6 to 7 times more than the values obtained by earlier workers for *Melolontha*.

Trehalase activity has been reported in insect muscle tissues wherever tested, except in the leg muscles of *M. differentialis* (DERR & RANDALL, 1966). In *V. nigricornis*, maximum activity was reported in thoracic muscle tissues rather than the other tissues. This result was not surprising because the thoracic muscles are actively engaged in flight activities. In the present insect, also, thoracic muscles show appreciable trehalase activity but the male muscle showed 2.58 times greater specific activity than those of female. This might be due to the fact that the male has to take more flights to locate the female for mating. Therefore, males may have more efficient trehalase enzyme to produce glucose as an energy source during flight activity.

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PARASITOIDS OF THE MANGO SHOOT CATERPILLAR *PENICILLARIA JOCOSATRIX* GUENEE (LEPIDOPTERA, NOCTUIDAE) IN SOUTHERN INDIA

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Pencillaria (*Bombotelia*) *jocosatrix* **Guenee (Lepidoptera: Noctuidae) infested mango trees in Karnataka, Kerala and Tamil Nadu in India. Five species of parasitoids were reared on it. Biological studies on** *P. jocosatrix* **and two of its parasitoids, a braconid,** *Aleiodes* nr. *circumscriptus* **Nees and an eulophid,** *Euplectrus* **sp. nr.** *parvulus* **Ferriere are reported.**

(*Key words: Penicillaria jocosatrix, Aleiodes* nr. *circumscriptus, Euplectrus* sp. nr. *parvulus*, biology, per cent parasitism)

INTRODUCTION

Penicillaria (*Bombotelia*) *jocosatrix* Guenee (Lepidoptera: Noctuidae) known to occur on mango (*Mangifera indica* L.) in Australia (HILL, 1915; JARVIS, 1946) China (WU & ZHU, 1981), Guam (USA) (R. MUNIAPPAN, Personal communication), India (AYYAR, 1963), Indonesia (VOUTE, 1934) and Sri Lanka (JEPSON, 1935). HAMPSON (1894) reported its occurrence on *Terminalia bellirica* (Gaertner) Roxb. in India. The only information available on its natural enemies is that of a parasitoid from Taiwan and three from India (BHATIA, 1948).

A one year survey was conducted in the mango orchards of Southern parts of Karnataka, Kerala and Tamil Nadu in India for *P. jocosatrix* and its natural enemies during 1986–1987. The observations made are reported here.

MATERIALS AND METHODS

Field survey:

Collections of *P. jocosatrix* for rearing its parasitoids was made in the following localities in Karnataka, Kerala and Tamil Nadu.

Karnataka: Bendegenahalli, CIBC Campus, Devanahalli, GKVK campus Hessaraghatta, Hoskote, Maddur, Magadi Road, Mysore Road and Tumkur Road (all in Bangalore District).

Kerala: Palghat District and Trichur District.

Tamil Nadu: Cuddalore, Kuttuchuddalore, Kuppanatham, Neyveli, Vadalur and Vriddhachalam. (Southern District of Arcot).

Laboratory rearing:

Rearing od *P. jocosatrix* was carried out throughout the year. In wooden cages

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measuring 30 × 30 × 30 cm with a wooden base, a large glass door in front and back and nylon mesh on either sides and top, proved successful in obtaining fertilised eggs. The cut ends of the mango twigs were kept submerged in water in a jar inside this cage. Aqueous solution of honey (50%) was provided in cotton swabs for the moth to feed. The cage was examined at 24 hour interval to remove the eggs and to replace the old mango twigs with fresh ones.

Eggs were transferred on to the tender mango leaves in glass jars, measuring 15 × 10 cm for rearing the younger larvae. Larger glass jars measuring 25 × 15 cm with a layer of sand at the bottom were given for pupation of later stage larvae.

The extent of damage by larval feeding was assessed by the percentage of leaf area fed by using a calibrated ocular sq. mm grid.

Twenty replications were maintained for studying the developmental periods of immature stages, longevity and fecundity of the moth and its parasitoids. Measurements of immature larval stages were taken immediately after killing by using a calibrated ocular micrometer.

All the studies were carried out under constant room temperature of 25° C and 50% relative humidity.

RESULTS AND DISCUSSION

Field observations

Incidence of *P. jocosatrix* was generally low in all the localities. However, a fairly severe infestation was observed at Vriddhachalam. In a mango orchard near Tumkur road *Penicillaria nugatrix* Guenee was also found in association with *P. jocosatrix*. Eggs were usually laid on tender leaves on which young larvae fed. VOUTE (1934) has also reported from Java that *P. jocosatrix* attacked the youngest leaves on which eggs were laid. Older larvae fed on slightly older leaves and rested on the abaxial surface of leaves. Pupae were found just below the infested tree in soil. Moths were active in the field at dusk.

Laboratory observations:

Penicillaria jocosatrix: Moths confined in smaller cages laid only unfertilised eggs. When released in larger cages most of the eggs laid were fertile. It appeared that some flight activity which occurred during night and was possible in bigger cages was necessary for the production of fertile eggs. Mating was seldom observed during day.

The pre-oviposition period was ten days. The eggs were mostly laid singly but sometimes in clusters of two or three on leaves, stems, and even on cotton wool, glass and nylon mesh in the bigger cages. The reproductive activity of the moths lasted for 8 to 12 days.

The egg was round and strongly ribbed with a flat base adhering to the substratum. The diameter varied from 600 μm to 696 μm ($\bar{X}$ 651.6 $\pm$ 28.92; n = 10). Freshly laid eggs were pale green, but turned yellowish-brown and later reddish brown with irregular spots appearing on the second day. Gradually the spots turned darker and just prior to hatching were nearly black. Unfertilised eggs did not develop pigment and eventually collapsed. The incubation period ranged from 2 to 3 days ($\bar{X}$ 2.3 $\pm$ 0.48; n = 10).

The larva cut open the chorion and wriggled out, taking about 40 to 45 minutes to completely extricate itself. The newly hatched larva was 3.4 to 4.0 mm long ($\bar{X}$ 3.76 $\pm$ 0.44; n = 10). Soon after hatching,

it moved to the tip of the leaf and fed on the parenchymatous tissue on the lower leaf surface by scraping and forming circular pits on the leaf. After feeding, it remained motionless for a minute and then moved to another spot on the lower or upper surface. During the early stage, it fed so little that it hardly had to move to another leaf. As the caterpillar developed, the colour changed to parrot-green. Feeding by the late instar larva caused deep scars and tender leaves were often completely devoured leaving only the mid-ribs. JARVIS (1946) has observed wilting of growing tips and die-back in Australia as a result of attack by *P. jocosatrix*.

There were 5 larval instars. After each moult, the larva fed on the cast skin. The duration of the larval period varied from 8 to 9 days ($\bar{x}$ 8.3 $\pm$ 0.46; n = 20), In Java, the larval period lasted for 10 to 11 days (VOUTE, 1934).

The first visible sign that the larva was ready for pupation was the change in its colour to reddish-brown. Its ventral side and intersegmental membrane remained green. Very often the caterpillar pupated in a case formed by fastening two leaves together. At other times, it pupated in the sand at the bottom of the jar. During the prepupal stage, which lasted for two days, the caterpillar shrunk and became smaller.

A newly formed pupa was light-green. As it aged, it turned brownish. The length of the pupa varied from 1.1 to 1.5 cm ($\bar{x}$ 1.3 $\pm$ 0.12; n = 15) and width from 0.3 to 0.4 cm ($\bar{x}$ 0.36 $\pm$ 0.06; n = 15). The pupal period lasted for 10 12 days ($\bar{x}$ 11.2 $\pm$ 0.62; n = 20). In Java too the pupal period was 12 days (VOUTE, 1934).

The image emerged at dusk. The female lived for 19 to 38 days ($\bar{x}$ 32.0 $\pm$ 5.13; n = 20) and the male for 12 to 29 days ($\bar{x}$ 22.5 $\pm$ 6.95; n = 20) feeding on 50% aqueous solution of honey.

When tender leaves of cashew, teak and castor were offered, the caterpillars accepted only cashew leaves.

Parasitoids:

Five species of parasitoids were reared. These were the braconid, *Aleiodes* (*Rogas*) nr. *circumscriptus* Nees, the eulophids, *Euplectrus* sp. nr. *parvulus* Ferriere and *Euplectrus leucostomus* Rohwer and the tachinids, *Blepharella lateralis* Macquart and *Peribaea* sp. The localities where the parasitoids were recorded with percentage of parasitism are presented in Table 1.

1. *Aleiodes* nr. *circumscriptus*

This is a solitary, larval endoparasitoid. Mating occurred among freshly emerged or between freshly emerged and older individuals. When a male came in contact with a female, the male mounted it clasping it with its forelegs. If there was no resistance from the female, copulation took place, the pair remianing motionless or the female dragging the male. Copulation lasted for 1.0 to 1.5 seconds ($\bar{x}$ 1.21 $\pm$ 0.25; n = 14). Copulation pairs were often interrupted by other males. Both males and females mated several times.

A female, whether mated or not, commenced oviposition within a few hours after emergence. It actively searched for the second or third instar host and on locating it thoroughly examined it with its antennae and pricked it several times with the ovipositor until the host was paralysed. It then fed on the host exudate and thrust the ovipositor into the host body and laid an egg. It took about 3 minutes to lay an egg, after which the host recovered in a few seconds and continued to feed for about

TABLE 1. Parasitoids of *Penicillaria jocosatrix* and their per cent parasitism in Karnataka, Tamil Nadu and Kerala.

Parasitoids	Per cent parasitism in :		
	Karnataka	Tamil Nadu	Kerala
Aleiode (*Rogas*), nr. *circumscriptus*	12.1	37.9	—
Euplectrus sp. nr. *parvulus*	—	00.5	—
Euplectrus leuscostomus Rohwer	22.5	—	—
Blepharella lateralis Macquart	3.7	26.3	—
Peribaea sp.	23.4	—	3.0
Total per cent of parasitism	61.7	64.7	3.0
Total no. collected	2021	2336	208

5 more days, but at a very much reduced rate. Parasitised hosts did not moult. The parasitoid attacked only second and third instars of the host.

A host larva on a mango leaf was more readily accepted than one offered without a leaf. It is possible that the host plant played some role in acceptance.

Dissections of host larvae immediately after parasitism revealed that only one egg was laid at an insertion. A freshly laid egg was elongate, slightly curved and narrow at both ends. The incubation period was 24 hours.

A newly hatched larva floated in the body of the host. As the parasitoid developed, the skin of the host larva changed its colour to cream, parrot-green and then brick-red, finally becoming a mummy. The larval period lasted for 5 to 6 days ($\bar{X}$ 5.5 $\pm$ 0.52; n = 16). The full grown parasitoid larva broke open the host skin ventrally, pushed out the host remnants and dried and fastened itself securely to the substratum. Pupation occurred within the host skin, the pupal period lasting 5 to 6 days ($\bar{X}$ 5.4 $\pm$ 0.48; n = 16). The host skin now measured 0.6 to 1.0 cm ($\bar{X}$ 0.8 $\pm$ 0.1; n = 14) in length and 0.2 mm is width.

A single adult emerged from each host, after making a hole on the upper side of the host skin.

The total duration of the immature stages lasted from 11 to 13 days, the average for 16 specimens being 11.87 $\pm$ 0.66.

Neither sex survived for more than one day without food. With 50% aqueous soultion of honey as food, the longevity of females varied from 26 to 40 days when not allowed to oviposit and of males from 30 to 35 days, average for 20 specimens being 35.0 $\pm$ 3.46 and 32.0 $\pm$ 2.92

respectively. Ovipositing females lived for 18 to 38 days ($\bar{X}$ 28.0 $\pm$ 5.70; n = 20).

Upto 12 eggs were laid per day. The total number of eggs laid by an individual varied from 96 to 251, the average for 20 females being 174 $\pm$ 39.89. The number of progeny of each that survived to the next generation ranged from 101 to 240 with an average of 164.0 $\pm$ 40.91 for 20 specimens.

The sex ratio of progeny of a single female was 1 female: 22 males. When more females and males were confined in a cage then the sex ratio of their progeny was 1 : 1.

2. *Euplectrus* sp. nr. *parvulus*

This is a gregarious, larval ectoparasitoid. Adults mated readily a few minutes after emergence. Repeated mating was quite common. In the presence of a female, the male bent his abdomen, vibrating the wings. If the female moved about, the male pursued it. The courtship lasted for 40 to 45 minutes, and copulation lasted for 1 to 2 seconds. The pre-oviposition period ranged from 1 to 6 days ($\bar{X}$ 2.7 $\pm$ 1.64; n = 20).

Eggs were deposited on second or third instar host larvae. When ready to oviposit, the female thoroughly examined the host. In an attempt to escape parasitism, the host used to swing its body, but the parasitoid quickly jumped on to the host and inserted the ovipositor. It laid 1 to 7 eggs in quick succession on a host ($\bar{X}$ 2.72 $\pm$ 0.81; n = 20). The host was not paralysed. The eggs were laid in groups, though not very closely and at any part of the body but firmly attached to the integument. The number of eggs laid by a female on a day varied from 1 to 14 ($\bar{X}$ 5.39 $\pm$ 0.63; n = 20). The maximum of 45 *Euplectrus platyhypenae* Howard were recorded on a single larva of *Laphygma* (CLAUSEN, 1940). The number of eggs laid on a host varied with the size of the host. NESER (1973) observed a clear correlation between the size of the host larva of *Plusia acuta* Walk and the number of eggs laid on it by *E.* sp. nr. *laphygmae* Ferriere.

SMITH (1927) reported that host larva died when eggs of *E. platyhypenae* hatched. WILSON (1933) observed that the parasitoid larvae completed feeding before the death of the host. NESER (1973) has reported that feeding by *P. acuta* soon after parasitism by *E.* sp. nr. *laphygmae* was normal, but decreased after parasitoid eggs hatched and stopped entirely within 24 hours of commencement of feeding by the parasitoids. Parasitised *P. jocosatrix* larvae continued to feed, but very little and died in the instar attacked; eggs laid on the final instar did not hatch.

Intermitent host feeding by the female was a common feature. The female sucked the body contents of the host for about 15 to 20 minutes invariably killing it in the end. No egg was laid on such hosts. The number of hosts thus killed for feeding by an individual parasitoid ranged from 21 to 38 in its life time. Host feeding has been observed in *E. parvulus* by CHATTERJEE (1945) and *E.* sp. nr. *laphygmae* by NESER (1973).

The egg was ovoid, both ends broadly rounded, shiny-white and with a smooth surface. It measured 72 to 96 μm in length and 48 to 72 μm in width, average for 11 specimens being 89.4 $\pm$ 3.2 and 53.0 $\pm$ 7.9 respectively. The incubation period lasted for 1 to 2 days with an average of 1.83 $\pm$ 0.13 for 18 specimens.

On hatching, the young larva remianed attached to the host body. A blusih-green

tinge appeared mid-dorsally and its intensity increased gradually. As the larvae matured, they moved on to the underside of the host remains, arranged themselves in a single row and pupated in loose silken strands, as in the case of *E.plartyhypenae* (CLAUSEN, 1940). Just prior to pupation, a full grown larva measured 2077 to 2294 μm ($\bar{X}$ 2191 $\pm$ 85.2; n = 13) in length and 1085 to 1240 μm in width ($\bar{X}$ 1189 $\pm$ 33.0; n=13). The larval period lasted for 4 days.

A newly formed pupa was cream-coloured, but turned black in 24 hours. The male pupa measured 1550 to 1612 μm ($\bar{X}$ 1591 $\pm$ 20.56; n = 10) and female pupa measured 1736 to 1953 μm ($\bar{X}$ 1866.2 $\pm$ 56.82; n = 10) in length. The width of the male pupa was 744 to 755 μm ($\bar{X}$ 761.7 $\pm$ 13.83; n = 10) and of female pupa was 868 to 930 μm ($\bar{X}$ 882.5 $\pm$ 46.9; n = 10). The pupal stage lasted for 5 to 6 days ($\bar{X}$ 5.11 $\pm$ 0.31; n=18).

The total duration of the immature stages was 10 to 12 days ($\bar{X}$ 10.94 $\pm$ 1.31; n=18).

Ovipositing females had a life span ranging from 55 to 83 days ($\bar{X}$ 67.0 $\pm$ 4.16; n=20) when fed with 50% aqueous solution of honey. Females that did not oviposit lived longer. Males lived for 51 to 79 days ($\bar{X}$ 63.0 $\pm$ 8.46; n = 20). The fecundity ranged from 232 to 462 ($\bar{X}$ 372.0 $\pm$ 70. 17; n = 20).

The number of caterpillars parasitised by an individual parasitoid varied from 86 to 175 ($\bar{X}$ 141.6 $\pm$ 30.25; n=20) while the number of progeny of a single female which successfully completed development varied from 156 to 326 females and 67 to 133 males average for 20 observations being 264.0 $\pm$ 53.8 and 97.0 $\pm$ 17.35 respectively.

The fact that this parasitoid kills the host not only by parasitising it, but also by host feeding enhances its importance as a potential biocontrol agent.

Food consumption by healthy and parasitised caterpillars:

A newly hatched larva fed only on the very tender leaves. As the larva grew older, it fed on older but still tender leaves. No feeding was noticed at all on fully mature leaves. During the first 72 hours, feeding was negligible. Thereafter, consumption increased and reached a peak from 120 to 192 hours. A healthy larva during its larval

TABLE 2. Leaf area (sq cm) consumed by healthy and parasitised larvae of *P. jocosatrix*

	Mean $\pm$ SD	Range	Feeding duration
Healthy larva	94.32 $\pm$ 24.48 (n = 15)	66.21 to 149.84	8 days
Parasitised by			
A. nr. *circumscriptus* 2nd instar.....	5.37 $\pm$ 1.46 (n = 11)	2.52 to 7.21	5 days
3rd instar	6.41 $\pm$ 0.76 (n = 8)	5.81 to 8.26	5 days
Parasitised by			
E. sp. nr. *parvulus*	1.48 $\pm$ 0.22	0.88 to 1.92	3 days

period of 8 days consumed as much as nearly a 100 sq cm of leaf area whereas when parasitised either by *A.* nr. *circumscriptus* or *E.* nr. *parvulus* the area consumed was less than 10 sq cm (Table 2).

Severe damage to mango due to *P. jocosatrix* has been reported from Queensland (Australia) by JARVIS (1946). The only other report of its occurrence as a major pest is from Gaum where it has assumed serious proportions in recent years (R. Muniappan, personal communication). In southern India, though *P. jocosatrix* is widespread, it is not a major pest. Perhaps the parasitoids play an important role in checking the population of *P. jocosatrix.*

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STUDIES ON THE LIFE OF *METASYRPHUS COROLLAE* (FAB.). A PREDATOR OF THE CABBAGE APHID (*BREVICORYNE BRASSICAE* L.) ON CAULIFLOWER SEED CROP

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Life table studies of a syrphid predator, *Metasyrphus corollae* (F.) revealed that this predator suffered high mortality due to large number of mortality factors. *Bacillus* spp. was found to be the major mortality agent besides parasitization mainly by *Diplazon multicolor* (Grav.) and *D. laetatorius* (F.).

(*Keywords:* life table, predator, *Metasyrphus corollae*, *Brevicoryne brassicae*)

INTRODUCTION

Among the cole crops cauliflower (*Brassica oleracea* L. var. *botrytis*) occupies the pride of place throughout the world. In India, these crops are grown over an area of 88,000 hectares (YAMAGUCHI, 1983). In the North-West Himalayas, cauliflower is grown as an off-season head crop during summer in the higher hills and as seed crop of late varieties during winter and spring in the hills. In Himachal Pradesh, cauliflower is attacked by more than two dozen insect pests, of which the cabbage aphid, *Brevicoryne brassicae* (L.) causes serious damage. Insect management programmes being developed for this crop include the use of biotic agents for the suppression of pest populations coupled with minimum use of insecticides. Among the naturally occurring motality agents of *B. brassicae*, syrphid predators are known to play an important role (GEORGE, 1957; POLLARD, 1971; STRAKA, 1976; AGARWALA *et al.*, 1984). However, under field conditions, these syrphid predators are attacked by a large number of parasites and predators, which tend to reduce the effectiveness of this predator. The present study was therefore undertaken to pinpoint the natural mortality agents of *Metasyrphus corollae* (F), which is one of the more commonly occurring syrphid predators of the cabbage aphid in the mid-hill regions of Himachal Pradesh.

MATERIALS AND METHODS

Cauliflower seedlings (Cv. 'Snowball-16') were transplanted in the third week of October during, 1986 and 1987 season. The seedlings were transplanted with 60 × 45 cm spacings and all the recommended practices were followed except plant protection in order to raise the crop in a pesticide free environment. Eggs were obtained in the laboratory from females of *M. corollae* and were transferred to the cauliflower plants in the field carrying natural infestation of *B. brassicae*. Since this predator passed only one generation in the cauliflower seed crop ecosystem, the life tables of only one generation could be constructed for two consecutive years

(1986, 1987) on this crop. For making the tables, column headings proposed by MORRIS & MILLER (1954) modified by MORRIS (1963) were used. The column used are as under:

x = the age interval between egg, larva and pupa or adult.

lx = the number surviving at the beginning of the stage noted in the x column.

dx = the number dying within the age interval in the x column.

dxf = the mortality factors responsible for dx.

100 qx = per cent apparent mortality

$$= \frac{dx}{lx} \times 100.$$

100 rx = per cent real mortality.

All the lx and dx values of the table represent the number of individuals per hundred plants of cauliflower. Since it was not possible to identify eggs of different syrphid species in the field, egg viability was determined by obtaining the eggs from the females in the laboratory and ultimately transferring them to the marked infested cauliflower plants in the field. Eggs were observed each day to obtain their dx values. The lx value for the first instar larvae was obtained by deducting egg mortality from the initial number while for others, it was based on direct sampling. For pupae, the lx value was obtained by collecting full grown larvae just before pupation and rearing them under laboratory conditions. For adult (flies), the lx value was based on the number of pupae giving rise to adults. N_2 value was obtained by counting the actual number of larvae in the next generation. However, this generation was not completed on the cauliflower seed crops.

RESULTS AND DISCUSSION

Life table of *M. corollae* for two consecutive years are presented in Table 1 and Table 2 which show an almost similar trend as far as survival of this species is concerned. Negative trend index values (I) (0.676 and 0.443) reveal that various mortality factors were responsible for the decline in the population. There was low survival as revealed by generation survival (SG) values 0.514 and 0.343 during 1986 and 1987 respectively. A comparison of the key mortality factors show that the generation survival during 1986 was affected to the maximum in the larval stage (k = 0.2443) mainly due to bacterial pathogen, certain unknown causes and parasitization by *Syrphophagus* sp. This was followed by reduction in the number of reproducing females (k = 0.2348) while during 1987 the generation survival value was affected to the maximum in the pupal stage (k = 0.2799) and the mortality agents were bacterial pathogen and two parasites *D. multicolor* and *D. laetatorius*. Mortality in the larval stage was same as in the case of reproducing females (k = 0.2430). During this year larval parasite *Syrphophagus* was not observed. Infertility in the egg stage due to certain unknown reasons was the other causes of mortality.

Trend index values during both the years were less than unity (0.676, 0.443), indicating that species suffered high mortality due to large number of mortality factors which caused decline in the population. This factor was further reflected in the generation survival value. In India, PATEL & PATEL (1969) reported *Diplazon orientalis* and *Syrphophagus* sp. parasitizing different syrphid larvae. *D. orientalis* was also reported as an important parasite of different syrphid species by RAO *et al.* (1981).

TABLE 1. Life table of *M. corollae* on cauliflower seed crop ecosystem during 1986.

x	lx	dxf	dx	100 qx	100 rx	log no.	k's
Egg	225	Infertility	26	20.44	20.44	2.3522	0.0993
		Unknown causes	20				
Larva							
I instar(N_1)	179	Bacteria (*Bacillus* sp.)	11	15.64	12.44	2.2529	0.0739
		Unknown causes	17				
II instar	151	Bacteria (*Bacillus* sp.)	13	16.56	11.11	2.1790	0.0786
		Unknown causes	12				
III instar	126	Bacteria (*Bacillus* sp.)	12	19.05	10.67	2.1004	
		Unknown causes	10				0.0918
		Parasite (*Syrphophagus* sp.)	2				
Pupa	102	Bacteria (*Bacillus* sp.)	9			2.0086	
		Parasite (*Diplazon multicolor*)	4	22.55	10.22		
		Parasite (*D. laetatorius*)	5				0.1110
		Parasite (*Syrphophagus* sp.)	5				
Adult	79	(Sex ratio 58.2%♀♀)	—	—	—	1.8976	
Reproducing females	46	—	—	—	—	1.6628	0.2348
Female x 2 (N_s)	92	Adult mortality	—	—	—	—	—
Total					64.88		0.6894

Real mortality = 64.88 per cent; Average fecundity per female 539

Expected eggs $= \frac{92}{2} \times 539 = 24794$; Dead/infertile eggs 5069; Viable eggs = 19725

Expected number of young larvae in the next generation 19725

Actual number of young larvae in the next generation (N_s) 121

Trend index (I) $= \frac{N_s}{N_1} = 0.676$ Generation survival (SG) $\frac{N_s}{N_1} = 0.514$

TABLE 2. Life table of *M. corollae* on cauliflower seed crop ecosystem during 1987.

x	lx	dxf	dx	100 qx	100 rx	log no.	k's
Egg	200	Infertility	39	30.00	30.00	2.3010	0.1549
		Unknown causes	21				
Larva							
I instar(N_1)	140	Bacteria(*Bacillus* sp.)	11	15.71	11.00	2.1461	0.0742
		Unknown causes	11				
II Instar	118	Bacteria (*Bacillus* sp.)	9	15.25	9.00	2.0719	0.0719
		Unknown causes	9				
III instar	100	Bacteria (*Bacillus* sp.)	9	20.00	10.00	2.000	0.0960
		Unknown causes	11				
Pupa	80	Bacteria (*Bacillus* sp.)	22			1.9031	
		Parasite(*Diplazon multicolor*)	7	47.50	19.00		
		Parasite (*D. laetatorius*)	9				0.2799
Adult	42	(Sex ratio 57.1%♀♀)	—	—	—	1.6232	
Reproducing females	24	—	—	—	—	1.3802	0.2430
Female x 2(N_8)	48	Adult mortality	—	—	—	—	—
Total					79.00		0.9208

Real mortality = 79.00 Average fecundity per female = 539 539

Expected eggs = $\frac{48}{2} \times 539 = 12936$ Dead/infertile eggs 3880; Viable eggs = 9056

Expected number of young larvae in the next generation 9056

Actual number of young larvae in the next generation (N_2) 62

Trend Index (I) = $\frac{N_2}{N_1}$ = 0.443 Generation survival (SG) = $\frac{N_2}{N_1}$ 0.343

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A COMPARATIVE STUDY ON THE EFFECTS OF DEHYDRATION DURING DIAPAUSE ON EMERGENCE, MORTALITY AND ADAPTABILITY OF MONO-, BI-, AND TRIVOLTINE VARIETY OF TROPICAL TASAR SILKWORM *ANTHERAEA MYLITTA* DRURY (LEPIDOPTERA: SATURNIDAE)

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Mono-, bi- and trivoltine cocoons of *A. mylitta* were subjected to constant dehydration stress for a period of six months. Observations on effects of dehydration stress on development, eclosion, post eclosion behaviour and mortality were made. The monovoltine variety could resist dehydration stress and can better adapt to this adverse condition during development. Normal moths of both sexes emerged and showed normal behaviour i.e., flight, copulation, survival and there was no visible structural deformity. The bi- and trivoltine cocoons were more susceptible to dehydration injury as reflected by mortality. The moths which emerged were deformed with short, crumpled, asymmetrical wings and relatively small body and abnormal morphology. They could neither fly nor copulate. It therefore seems that optimal moisture requirement is more critical factor for pupal development in bi- and trivoltine varieties than the monovoltine ones, which has better adabtability for water conservation and utilization during development.

(*Key words:* Tasar silkworm, monovoltine, bivoltine, trivoltine, dehydration, eclosion, diapause, adaptability, pre-eclosion age)

INTRODUCTION

Insects being poikilotherms and imperfect regulators unlike homeotherms depend to a great extent on the ambient environmental conditions. Insect in tropical regions adopt a combination of strategies to avoid the damaging effects of exposure to wide range of temperature and humidity during different seasons.

The tasar silkworm a non-mulberry, sericigenous species is mostly confined to tropical belts of India where physical factors like temperature, humidity, wind velocity, photoperiod etc. fluctuate widely during different seasons. It passes through a period of diapause. Humidity requirement during diapause has not been extensively studied in tropical sericigenous insects, though dehydration of an organism has been frequently regarded as an important cause of abnormal development and the onset or breakdown of diapause in insects. Due to the paucity of information on the effects of moisture deprivation during development in tropical tasar silkworm *A. mylitta*, it was felt necessary to study and compare the effects of dehydration in diapausing pupae, in the three voltine varieties, particularly on their emergence, mortality, adaptability and post-emergence behaviour.

MATERIALS AND METHODS

Mono-, bi-, and trivoltine varieties of cocoons of *A. mylitta* with live papue were

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collected at random from Mayurbhanj district of Orissa. All the three varieties were segregated into batches. One batch of each variety was kept in normal laboratory condition (which varies from 26 ± 1°C and 70 ± 5% RH during December to 29 ± 1°C and 88 ± 5% RH during May/ June with usual photoperiod) treated as control. The other experimental batches were subjected to dehydration stress by keeping them in different desiccators containing adjusted amount of fused calcium chloride to maintain an RH of 20%. The RH of the desiccators containing fused calcium chloride were measured using a hygrometer (Springfield, USA). Initially the weight of both control and experimental cocoons were taken. For this study 20 cocoons for control and 15 cocoons as experimental in monovoltine, 12 cocoons for control and 20 for experimental in bivoltine and for trivoltine 25 cocoons for control and 13 cocoons for experimental purposes were used. The weight of the cocoons was taken in both the batches from 1st December (pre-eclosion age of moth six) to 1st June (pre-eclosion age of moth 0 i.e., the approximate time for moth emergence) at 7 days interval but for convenience the data was plotted in the graph month-wise. The weight measurements were done using a sensitive monopan balance (Mettler-163).

RESULTS

Our results indicate that the response to dehydration stress of the three varieties of cocoon of *A. mylitta* i.e., mono-, bi- and trivoltine variety are different. Fig. 1 indicates rate of dehydration or moisture loss under normal and experimental conditions as mentioned by the change in

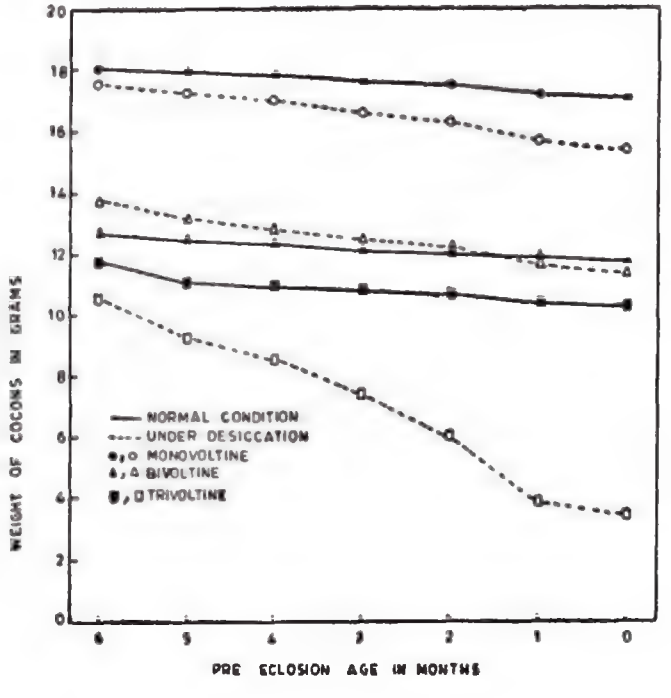

Fig. 1 Rate of dehydration under normal and experimental conditions in mono-, bi-, and trivoltine varieties of *Antheraea mylitta* cocoons.

weight of cocoons. The weight change profile under normal and experimental conditions in monovoltine variety was from 17.99 to 17.08 g and from 17.48 to 15.41 g respectively. In the bivoltine the weight changes from 12.74 to 11.83 g in normal condition and 13.71 to 11.42 g in experimental conditions and in trivoltine from 11.72 to 10.26 g in normal condition and from 10.49 to 3.55 g in experimental conditions (Table 1).

From the weight change pattern the trivoltine seems to be most susceptible whereas the bivoltine was intermediate and the monovoltine was least under dehydration stress.

The rate of mortality under dehydration stress was maximum in trivoltine (100%), whereas in bivoltine about 10% and in monovoltine mortality had not occurred at all.

The moths which emerged from the cocoons under normal conditions were fully formed, showed normal post-emergence behaviour.

However, the moths which emerged under experimental conditions from the cocoons of trivoltine variety were small, deformed with rudimentary wings and could neither fly nor copulate, whereas the percentage of survival, growth pattern, emergence and the post emergence behaviour of the moths from monovoltine variety were normal. In bivoltine even though emergence was intermediate the mortality was higher, and the moths emerged were abnormal in their wing size, wing expansion, flight ability and copulation (Fig. 1).

DISCUSSION

Since these three varieties have their specific time bound and genetically programmed developmental patterns, the mechanism and the strategy employed for water conservation, utilization and dependence are likely to be different.

The monovoltines seem to be the most resistant variety to dehydration stress which has been compensated by prolonging its developmental period by undergoing much

TABLE 1. Change in weight of monovoltine, bivoltine, trivoltine cocoons of *A. mylitta* during development under normal conditions and dehydration stress.

Pre-eclosion age of pupae in month.	Normal condition (control)			Dehydration stress		
	Monovoltine ± S. E. M. (g)	Bivoltine ± S. E. M. (g)	Trivoltine ± S. E. M. (g)	Monovoltine ± S. E. M. (g)	Bivoltine ± S. E. M. (g)	Trivoltine ± S. E. M. (g)
6	17.998±0.359	12.739±0.705	11.720±0.483	17.477±0.475	13.707±0.573	10.488±0.916
5	17.947±0.359	12.488±0.655	10.982±0.442	17.226±0.477	13.172±0.571	9.155±0.942
4	17.796±0.359	12.346±0.663	10.892±0.438	16.971±0.479	12.777±0.574	8.456±0.951
3	17.644±0.361	12.242±0.664	10.825±0.435	16.629±0.486	12.451±0.571	7.432±0.985
2	17.532±0.359	12.103±0.663	10.691±0.427	16.289±0.481	12.137±0.570	5.953±0.979
1	17.230±0.359	11.905±0.658	10.435±0.422	15.662±0.477	11.669±0.569	3.773±0.607
0	17.075±0.360	11.831±0.662	10.264±0.448	15.410±0.481	11.421±0.609	3.346±0.249

longer diapause. Perhaps the thickness and poor porocity of cocoons shell wall, as well as the pupal cuticle and low metabolic rate facilitate this water conservation mechanism, slow water utilization and relatively less dependence on ambient moisture. The bi- and trivoltine being relatively faster in their development and annual repetative life cycle, metabolically seems to be more dependant on optimum moisture for their development.

The result also indicates that the optimum moisture availability is critical for the development of the trivoltine variety. Loss of humidity beyond critical value may hamper the development, growth and emergence of bivoltine and trivoltine variety of *A. mylitta*. Aerial dehydration forms a major problem among terrestrial arthropods. As the water activity of their haemolymph ranges from 0.995 to 0.998 (i. e. 300–600 m Osm/kg), unless the water vapour activity of the ambient air is saturated the activity gradient favours the net loss of water from the animal to the atmosphere by diffusion. Although water loss tolerances vary considerably between arthropods (ARLIAN & VESELICA, 1979), many arthropods regulate their body water content between relatively narrow critical limits (COOPER, 1985; SELL & HOULIHAN, 1985).

The larval development of *Galleria mellonela* has been reported to be higher in 80% RH than dry one (CHOUVIN & CHAUVIN, 1985). ROTHERAY (1986) observed that optimum moisture is required for the normal emergence of *U. vardui* from its gall. Fall of humidity below a critical level (as low as 18% RH) affects the pupae of *A. mylitta* in their differentiation, development, emergence and post-emergence behaviour.

Analysis of variance shows that the variations between control and experimental groups was significant ($P<0.001$).

The maximum tasar producing areas are in the tropical belt of India where the tasar silkworm *A. mylitta* are exposed to greater range of temperature and moisture fluctuation during their developmental periods. Hence, of all other factors, humidity during development may be highly influential one on emergence. By controlling this particular parameter one can successfully maintain the culture of any particular variety of tropical tasar silkworms during diapause and development.

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FEEDING AND REPRODUCTIVE POTENTIAL OF TWO SPECIES OF TORTOISE BEETLES (COLEOPTERA : CASSIDIDAE)

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Feeding and reproductive preference of two species of tortoise beetles, *Chirida bipunctata* F. and *Metriona circumdata* H. (Coleoptera : Cassididae), on Ipomaceous weed hosts, *Ipomaea obscura* Ker Caul and *I. panniculata* R. Br. were investigated. Feeding and food consumption of fifth instars and adults of both species varied significantly on the two weed hosts tested. The beetles preferred to feed on *I. obscura*. The pattern of egg laying also revealed strong preference towards *I. obscura*. The food plant preference by two species of beetles are discussed in terms of the nutritional qualities of the weed hosts as well as previous feeding preferences.

(*Key words :* feeding, reproductive preference, tortoise beetles)

INTRODUCTION

Growth and reproduction of phytophagous insects are significantly influenced by quality and quantity of food consumed. The amount, rate and quality of food consumed by larva not only affects its own performance, but also the performance of the emerging adult (SLANSKY, 1980). In the chrysomelid beetles, *Leptinotarsa decemlineata* Say (DEWILDE *et al.*, 1969) and *Haltica lythri* Aubo (PHILLIPS, 1976), food consumption and egg laying were profoundly influenced by the age of leaves. Similarly, in the red pumpkin beetle, *Raphidopalpa foveicollis* Lucas, the host selection and food utilization were influenced by the biochemical composition of leaves (RAMAN & ANNADURAI, 1985). The tortoise beetles, *Chirida bipunctata* F. and *Metriona circumdata* H. are reported to be pests of sweet potato, *Ipomaea batatas*. These beetles exhibit strict host specificity and utilize only plants belonging to the family Convolvulaceae which include the cultivated species of sweet potato and other weed hosts. Though the pest status of *C. bipunctata* and *M. circumdata* are well known, information on the utilization of weed hosts by the beetles is lacking. The present paper therefore highlights the feeding and reproductive preference of two species of tortoise beetles on the Ipomaceous weed hosts.

MATERIALS AND METHODS

Cultures of *C. bipunctata* and *M. circumdata* were maintained in the laboratory separately on the two different weed species for two generations. Insects required for the experiments were drawn from these cultures.

Feeding studies:

The feeding was assessed in terms of the age of leaves, area of leaf fed, and the amount of food ingested by the two species of tortoise beetles. For this newly moulted 5th instars and adults (male and female) were confined on the respective host plants for a period of 24 h. Observations were recorded on the number of feeding sites,

total area of leaf fed, and the amount of leaf consumed by the insects. The total area of leaf fed was computed by transferring the area fed by the beetles on to a graph sheet and then expressing it in terms of sq mm area of leaf fed. The amount of leaf consumed was calculated by multiplying the area of the leaf fed with the fresh weight of a known area of an undamaged leaf of the same age and size. In addition, computation was also made on the size of feeding sites by the beetles. The size of feeding sites were expressed in sq mm and grouped into various frequency classes to ascertain the pattern of feeding by the beetles on the weed hosts.

TABLE 1. Impact of leaf age on feeding and food consumption of two species of tortoise beetles.

Species of insect	Host plant	Plant part	Number of feeding sites/day		Total area fed/day (sq mm)		Amount of leaf consumed/day (mg)	
			Adults	5th inst.	Adults	5th inst.	Adults	5th inst.
	Ipomaea panniculata	Y	6.25± 0.12	4.10± 0.15	36.45± 1.73	11.00± 0.01	0.12± 0.02	0.08± 0.01
		M	15.20± 2.19	9.20± 0.37	64.55± 2.15	52.60± 1.86	2.13± 0.02	1.70± 0.03
Chirida bipunctata		t-value	4.00**	4.23**	5.16**	4.76**	3.68**	2.40*
	Ipomaea obscura	Y	8.75± 1.12	5.16± 0.50	54.55± 2.15	16.14± 1.12	0.22± 0.10	0.11± 0.10
		M	29.00± 2.06	10.80± 0.37	80.50± 3.27	63.60± 9.62	2.82± 0.03	2.10± 0.01
		t-value	4.23**	3.00**	3.67**	3.41**	2.86*	4.57**
	Ipomaea obscura	Y	11.40± 0.02	7.11± 1.12	42.10± 1.60	20.00± 0.92	0.29± 0.02	0.16± 0.01
		M	21.40± 2.00	11.28± 0.21	84.55± 5.13	59.00± 0.64	2.96± 0.01	2.07± 0.02
Metriona circumdata		t-value	3.29**	3.32*	4.07**	2.46*	2.59*	3.15**
	Ipomaea panniculata	Y	10.50± 0.01	5.12± 0.10	24.10± 0.04	15.60± 0.12	0.85± 0.03	0.55± 0.02
		M	19.30± 0.10	10.00± 0.05	42.80± 0.01	37.40± 0.03	1.40± 0.30	1.23± 0.10
		t-value	3.15**	4.25**	3.87**	3.27**	2.35*	3.11**

Values indicate mean of 5 replicates ± S.E.
@ calculated on the basis of fresh weight of a known area of an undamaged leaf of similar age and size.
Y – Young; M – Mature.
* Significant at 5%.
** Significant at 1%.

Reproductive studies:

This was determined by computing the life-cycle and fecundity of *C. bipunctata* and *M. circumdata* on the weed hosts. The egg laying of the two species of beetles on the weed hosts was also determined. The 'fecundity index' was assessed by taking the ratio of the total number of eggs laid by female during its life-cycle and the number of days taken for the same.

Biochemical analysis:

In order to assess the nutritional quality of the host plants, the leaves of the two species of *Ipomoea* plants were separately analysed for evaluation of their contents of total nitrogen using Kjeldahl's method (VOGEL, 1963) and of their total proteins (LOWRY *et al.*, 1951), carbohydrates (DUBOIS *et al.* 1956), and phenols (BRAY & THORPE, 1954) colorimetrically.

RESULTS AND DISCUSSION

Data from the study indicate significant differences in the feeding and food consumption by the two species of tortoise beetles, *C. bipuncatata* and *M. circumdata* on the weed hosts, *I. obscura* and *I. panniculata*. In general, larva and adult of both species showed strong preference to

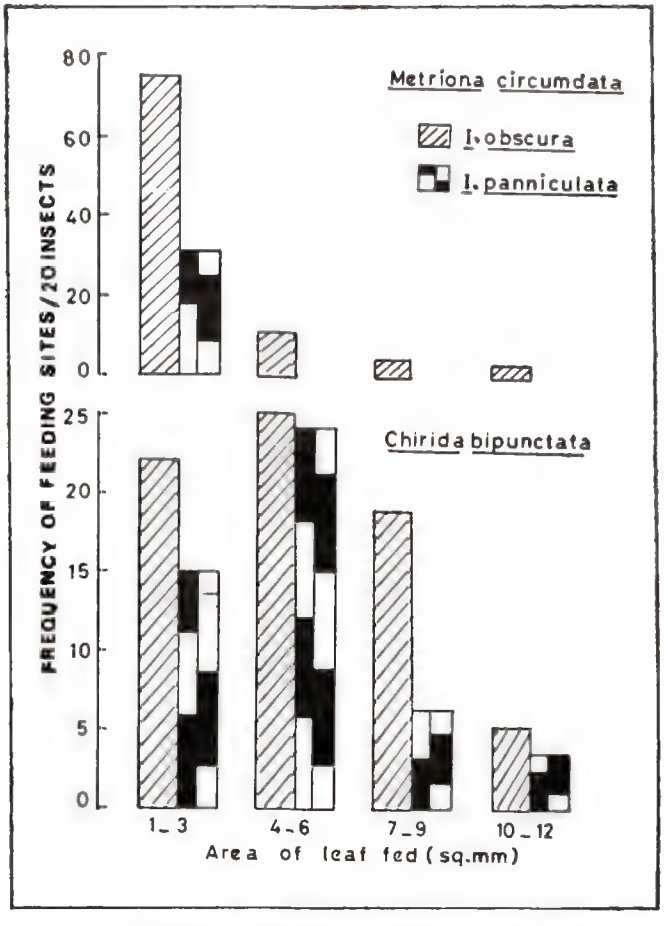

Fig. 1. Frequency of feeding sites by tortoise beetles.

feed on the mature leaves compared to young ones. This was clearly evident by the number of feeding sites, area of leaf fed, and the amount of leaf consumed on mature leaves by *C. bipunctata* and *M. circumdata* (Table 1). Incidentally, studies on the orientational pattern of the tortoise beetles have revealed significant preference of larva and adult towards mature leaves when compared to other parts of the plant such as stem, flower buds, flowers etc. (unpublished data). However, we found that the food consumption of fifth instars and adults of *C. bipunctata* and *M. circumdata* significantly varied on the two species of host tested. Both beetle species showed preference to feed on the host *I. obscura* than *I. panniculata*. Further the size of feeding sites in terms of the area of leaf fed also varied for the two beetle species depending upon the nature of weed hosts fed. The area of leaf fed by *M. circumdata* was only within 1–3 sq mm, rarely exceeding this limit and if so only when the host is *I. obscura*. On the contrary, *C. bipunctata* inflicted greater damage to both *I. obscura* and *I. panniculata*, the maximum feeding range bei ıg 4–7 sq mm (Fig. 1).

The present study also showed a definite relationship between the age of the leaf and the amount of leaf eaten by the two species of beetles. The nutrient contents of plant vary with age, and the distribution of many phytophagous species often closely reflect pattern of host nutrients (CATES, 1980). In the present study also the preference of *C. bipunctata* and *M. circumdata* was more towards the mature leaves of the host *I. obscura* compared to *I. panni culata*. This could be attributed to increased nitrogen, proteins, and carbohydrates, and low phenols in the mature

TABLE 2. Life-cycle of *C.* bipunctata and *M. circumdata* on two species of *Ipomaea*.

Parameters	*C. bipunctata*		*M. circumdata*	
	I. obscura	*I. panniculata*	*I. panniculata*	*I. obscura*
Incubation period @	5.00±0.01	6.33±0.34	5.33±0.34	4.67±0.34
Larval period @	10.67±0.34	14.33±0.34	13.33±0.67	8.67±0.34
Pupal period @	4.00±0.01	4.67±0.34	4.67±0.34	3.67±0.34
Pre-oviposition period @	7.33±0.34	12.67±0.34	13.67±0.34	8.67±3.34
Reproductive period @	56.00±5.33	36.00±2.09	18.67±2.21	53.67±4.21
Longevity @				
Male	53.67±8.75	54.00±1.16	55.67±1.46	63.00±1.16
Female	60.67±1.78	60.67±4.40	60.33±0.89	66.33±1.21
Mean number of eggs laid/female	20.08±1.22	16.94±0.79	12.58±1.61	24.40±0.84
Fecundity index	50.57	27.90	22.25	55.38

Values indicate mean ± S. E.
@ days.
Each experiment was repeated three times.

TABLE 3. Biochemical composition of *Ipomaea* species.

Host plants		Nitrogen (%)	Proteins (mg/g fresh weight)	Carbohydrates (mg/g fresh weight)	Phenols (mg/g fresh weight)	Moisture (%)
I. panniculata						
leaves	Young	4.25±0.01	2.42±0.02	1.40±0.01	28.00±0.01	82.00±0.22
	Mature	5.19±0.03	2.80±0.01	1.75±0.04	14.00±0.20	79.00±0.03
I. obscura						
leaves	Young	2.34±0.01	2.77±0.11	1.50±0.05	40.00±0.01	77.00±0.10
	Mature	6.13±0.21	3.70±0.22	2.65±0.02	19.00±0.11	73.00±0.20

Values indicate mean of 4 replicates ± S. E.

leaves (Table 3), which has resulted in not only greater preference but also increased food consumption by the two beetle species. This supports the observations made by RAMAN & ANNADURAI (1985).

Table 2 indicates the details of the life-cycle of *C. bipunctata* and *M. circumdata* on the weed hosts. Data show that weed plants influence the life-cycle of the test insects. Larval and pupal development were faster for both the species on the host *I. obscura* compared to *I. panniculata.* Similarly, computation of the total reproductive period, number of eggs laid by a female, and the fecundity index for *C. bipunctata* and *M. circumdata* indicated *I. obscura* to be the most preferred than *I. panniculata.*

SLANSKY (1980) attributed that the number of eggs laid by an insect show a close relationship to the amount of food consumed and any lack of or poor quality food for the adult female may cause a delay in the onset of egg-production as well as a reduction in the rate of egg laying. Thus, the higher reproductive rate of *C. bipunctata* and *M. circumdata* on the weed host *I. obscura* observed in the present study is not only due to the higher amounts of the leaf consumed by the adult females but also to the nutritional superiority of the host compared to *I. panniculata.* SCHOONHOVEN & MEERMAN (1978) concluded that insects utilized food to which they are adapted more efficiently than a novel food. Moreover, such physiological adaptations to certain food was regarded as a functional reason underlying changes in food selection behaviour due to previous experiences. We observed that under field condition both the beetle species were feeding on the weed host *I. obscura* and *I. panniculata.* However, when their preference was studied it was evident that the beetles exploited *I. obscura* in a better manner than the host *I. panniculata.* It remains to be tested whether the food plant utilization by *C. bipunctata* and *M. circumdata* also involve any 'previous experience' in feeding in addition to the nutritional suitability of the weed hosts.

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POTENTIAL OF FOUR INSECT GROWTH REGULATORS IN HOUSEFLY CONTROL

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Four Insect Growth Regulators (IGRs), Dimilin, OMS 3031 (XRD-473), Methoprene and OMS 3013 were assessed for their potency in controlling houseflies. Among four IGRs, methoprene was found to be the most promising (EI_{50} - 0.0503 mg/l) followed by OMS 3031 (EI_{50} - 0.7552 mg/l). Maximum larval mortality was observed in the case of OMS 3031 (56% at 1.0 mg/l) followed by Dimilin (52% at 3.0 mg/l): Higher proportion of morphogenetic aberrations in pupal stage was induced by OMS 3013 and Dimilin at higher concentrations (1.0 & 1.8 mg/l). Various adult deformities observed in adults were maximum in methoprene treated larvae and minimum in the case of OMS 3031 treated larvae. Inhibition of emergence in adult houseflies in F_2 generation was also noticed when treated with IGRs in F_0 generation in the larval stage.

(*Key words:* dimilin, methoprene, OMS 3031, OMS 3013, IGR activity, *Musca domestica*)

INTRODUCTION

Houseflies are non-biting muscoid flies acting as mechanical vector of many faecal bacteria, viruses and protozoans as they often infest dairy farms, poultry ranches, chicken manure, pigfarms and cattle feed lots. The diseases with which they are most commonly implicated are typhoid and dysentry, that pose a great public health problem. Though frequent and thorough removal of filth and manure spilt stuffs discourage housefly development, it is not always possible due to various reasons and many farmers depend on insecticides for fly control (Baily *et al.*, 1968). Since resistance has been monitored in house flies to almost all insectides which are in current use (Mulla & Axelrod, 1983), a new alternative is sought which would overcome the problems met with conventional insecticides. In recent years, IGRs have shown promise in fly control by being selective, specific, less prone to resistance development and harmless to non-target organisms. IGRs offer excellent potential for the control of filth and manure breeding flies when applied to breeding medium, used as feed additive, incorporated with water, mineral or salt blocks or placed as a sustained release boluses in large animals (Breedan *et al.*, 1976, 1977; Miller *et al.* 1975; Townsend & Turner, 1978; Williams & Berry, 1980; Miller, 1982; Miller & Schmidtmann, 1985). In the present investigation the control potential of four IGRs have been studied against *Musca domestica* in the laboratory.

MATERIALS AND METHODS

Four insect growth regulators (IGRs), diflubenzuron (25% wp), methoprene (10% ws), OMS 3031 (XRD 473, 5% EC) and OMS 3013 (5% EC) used in this study were received gratis from WHO, Geneva, of which the former two are registered for use. The formulations were diluted in alcohol/water to make 0.1% stock solution from which further dilutions were made in water to acquire the desired concentrations in the larval rearing medium.

Emergence inhibition and morphogenetic aberrations in the laboratory strain of *Musca domestica* were monitored by rearing II instar larvae in fly medium (rice bran and ground nut oil cake powder in the ratio of 3:1) treated with various concentrations of IGRs. The required amount of toxicant was added to 60 ml of water; the water with the materials was then added to 40 g of the fly rearing medium and mixed thoroughly to yield 100 g of wet medium with the desired concentrations of IGRs. Each of the treated media batches (100 g) was placed in glass beakers. Four replicates were run for each concentration with untreated batch as control. Each test was repeated thrice at temperature 28 ± 2° C and humidity 75 ± 5%. Observations on adult emergence and abnormalities were recorded. Emergence inhibition was determined by considering the larval mortality, pupal mortality, incompletely emerged and abnormal adults. EI_{50} and EI_{90} values were calculated by probit analysis and Abbots formula (FINNEY, 1971) was used to correct mortality in treatments in relation to control mortality. Adults emerged from treated puparia were maintained separately on milk powder and water to observe the delayed effects of IGR treatment on the emergence of F_2 generation.

RESULTS AND DISCUSSION

The control potential of four IGRs on *M. domestica* is presented in Table 1. From the results it is evident that the IGRs, particularly methoprene, effected considerable inhibition in adult emergence. When EI_{50} of four IGRs were compared, methoprene was found to be the most promising and about six times more potent than dimilin, followed by OMS 3013 (about four times) and equally effective as OMS 3031. Complete inhibition in adult emergence was obtained for methoprene, OMS 3031 and OMS 3013 at dosages between 1.0–1.5 mg/l, and for dimilin only at 3.0 mg/l. However, the level of emergence inhibition induced by these IGRs is comparatively higher than that obtained for IGRs reported earlier (MILLER *et al* 1975; HALL & FOCHSE, 1980; FARKAS, 1986).

Varying degrees of morphogenetic abnormalities were recorded at increasing dosages of IGRs (Fig. 1). Percentage larval mortality was lesser at all concentrations except in OMS 3031 (56% at 1.0 mg/l) and dimilin (52% at 3.0 mg/l). The higher the concentration, more the pupal mortality or emergence inhibition noted particularly with OMS 3031 and dimilin treated larvae. Most of the treated

TABLE 1. Effect of four IGRs on the adult emergence of *M. domestica*.

Name/Code	EI_{50}	EI_{90}	Regression	X^2	LCL-UCL (for EI_{50})
Methoprene	0.0503	0.6404	Y = 6.504 + 0.503 lnX	4.855	0.038 – 0.050
Dimilin	0.3154	2.4484	Y = 5.721 + 0.625 lnX	25.156*	0.243 – 0.394
OMS 3031	0.1378	0.7552	Y = 6.491 + 0.758 lnX	7.979	0.113 – 0.168
OMS 3013	0.2099	0.9370	Y = 6.336 + 0.856 lnX	13.055*	0.177 – 0.249

* — Heterogenity.

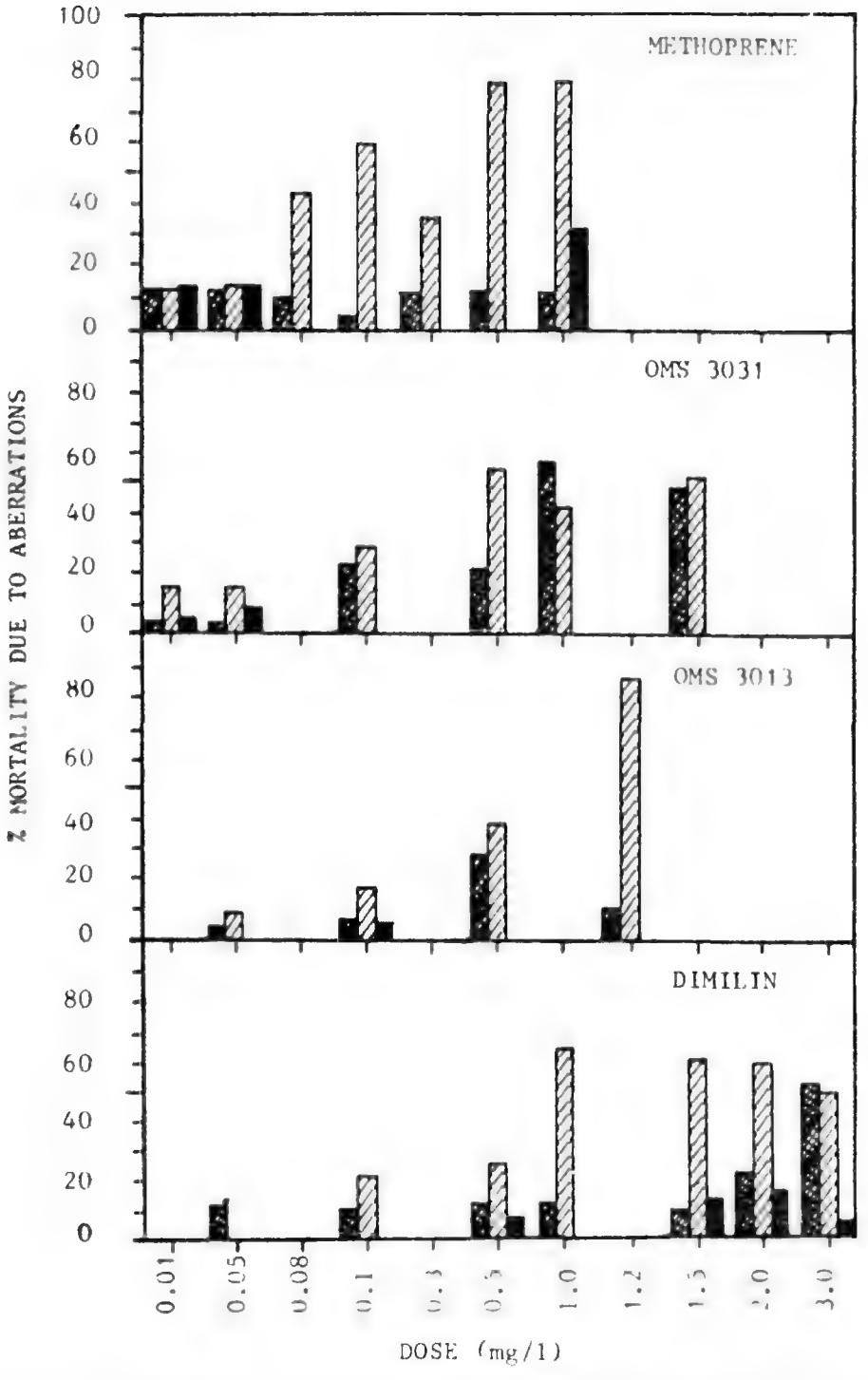

Fig. 1. Percentage mortality due to abberation in larvae, pupae and adults induced by four IGRs at different concentrations after treatment of second instar larvae of *Musca domestica*.

larvae were able to pupate; however, some of the resultant puparia assumed larviform, rodlike, C-shaped, deformed or elongated forms which were the most prevalent morphogenetic aberrations (Fig. 2A-E). The larviform puparia were significantly ($P < 0.05$) longer (9.5 ± 0.45) than the normal pupae (6.0 ± 0.27) and shorter than normal larvae (10.0 ± 0.58). Very few adults emerged partially or completely from morphologically aberrant puparia but were found to have various deformities which was maximum in methoprene treated larvae and minimum in the case of OMS 3031 treated larvae. In most cases only the head emerged and in some cases head and thorax emerged from puparia. In other cases, the head thorax, part of the abdomen or the entire abdomen and some of the legs emerged, but the adults were still attached to the puaprium by legs (Fig. 2F-H). Similar observations were also made with *M. domestica* treated with other IGRs (AWAD & MULLA, 1984). Deformity of one or both the wings or lack of wing expansion was common. Partially or wholly eclosed adults having crumpled wings were also noticed (Fig. 2i). Adult flies with

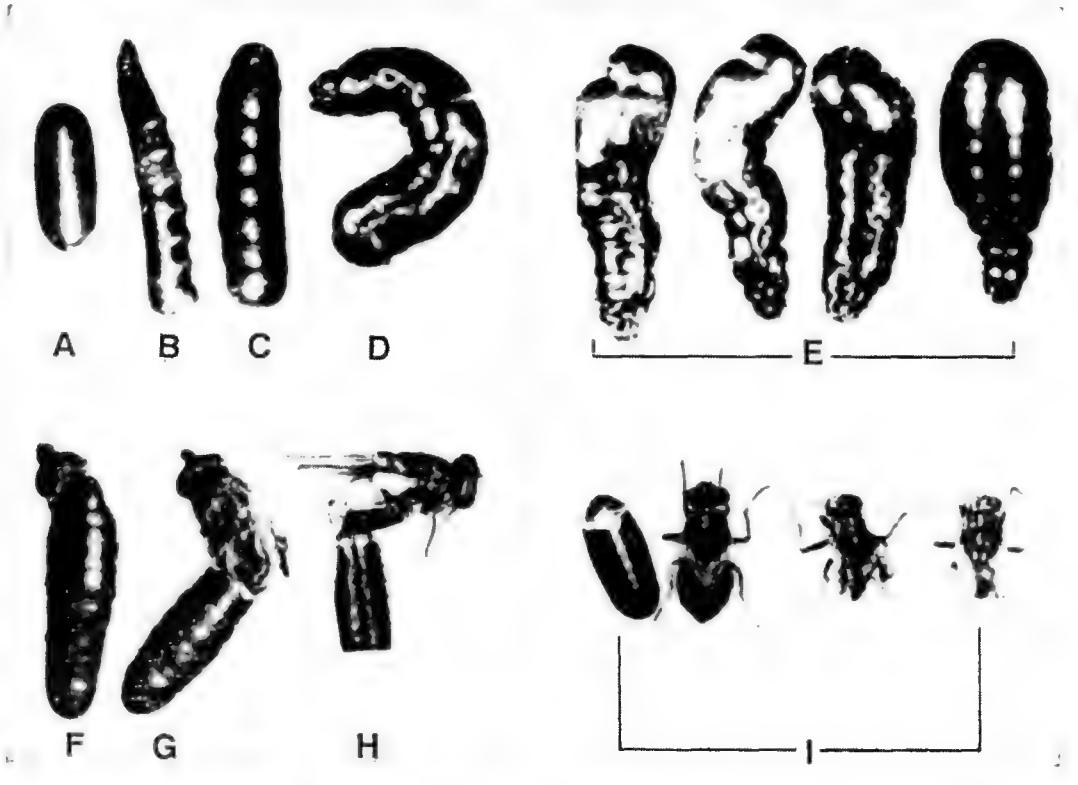

Fig. 2. Pupal and adult abnormalities induced by IGRs at different concentrations after treatment of II instar larvae of *Musca domestica*.

A. Normal puparium; B. Larviform puparium; C. Elongated puparium; D. 'C' shaped puparium; E. Deformed puparia; F. Only adult head eclosed; G. Adult partially eclosed with legs and part of the wings attached to the puparium; H. Adult attached to the puparium by legs; I. Normal adult; and deformed adults with crumpled wings and reduced abdomen.

TABLE 2. Emergence Inhibition in F generation of *M. domestica with methoprene*, OMS 3031 and OMS 3013.

Dosage applied (mg/l)	Emergence Inhibition (%)		
	OMS 3031	Methoprene	OMS 3013
0.01	49	41	30.0
0.05	84	50	37.5
0.1	86	54	50.0
0.5	**	*	*
1.0	*	*	*

* — No egg laying.
** — Eggs laid but no emergence of adults.

non-retractile wings were unable to fly and died soon after emergence as also observed by FARKAS (1986).

Among the three IGRs tested (OMS 3031, OMS 3013 and methoprene), maximum inhibition in adult emergence was produced by OMS 3031 at the dose of 0.1 mg/l in F_2 generation. The adults of F_2 generation treated with the three IGRs at higher dosages (0.5 and 1.0 mg/l) failed to lay eggs. Even when eggs were laid, no emergence of adults could be observed.

Application of IGRs in the premetamorphic stage will prevent metamorphosis irreversibly and lead to non-viable intermediates, non-emergence of adults and/or suppression or inhibition of reproduction. Application to last larval instars is most effective and to earlier larval instars is usually somewhat less effective and due to inactivation and excretion of the active ingredient before the time of maximum sensitivity in the last larval instars (WHO, 1983). In contrast, deformities of puparia are greater following treated eggs or first instar or second instar larvae and decreased with maturation of stage treated (WEAVER & BAGELEY, 1982). Methoprene (ZR–515), the juvenile hormone analogue is one of the most thoroughly investigated and safest materials currently available for the control of insects (RETNAKARAN *et al.*, 1985). Diflubenzuron does not adversely affect many of the non-target fauna in manure, including many predators and parasites which may be useful as biological control agents of the fly population. Diflubenzuron, the insect growth inhibitor is of low toxicity to vertebrates and is suitable and effective when mixed into the feed of poultry or pigs to kill the larvae of fly in excrements (KCIDING, 1986). The IGRs are often bio-degradable and formulations can improve stability of the active ingredients. The great advantages of these compounds consist in their safety in environmental terms, the selectivity of their action and their low level of toxicity for warm blooded creatures (ANONYMOUS, 1983). In future, this endocrine method of control may prove to be both economical and practical in Integrated Pest Management programmes.

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NEST ASSOCIATED ACARINES OF INDIA WITH DESCRIPTIONS OF SEVEN NEW SPECIES AND NOTES ON OTHER ARTHROPOD ASSOCIATES

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Seven new species *viz.*, *Steatonyssus lonchura*, *Neoeucheyla ploceus*, *Microcheyla bengalensis*, *Pronematus saularis*, *Acheles inornata*, *Acheles pycnonotus* and *Lasioseius malacca* **collected from bird nests in West Bengal, India are described and illustrated. Besides, other 52 species of acarines known from bird nests in India and a list of various arthropodan groups collected by these authors from bird nests are also dealt with.**

(*Key words:* new acarines with arthropod associates, bird nests, India)

INTRODUCTION

It is an established fact that birds' nests provide a characteristics ecological niche which harbour varied arthropod fauna of which the acarines are the most dominant ones. Several studies such as Moreau (1942), Hoyt (1948), Woodroffe (1943), Nolan (1955), Baker *et al.* (1976), Philips & Dindal (1979) etc., from overseas and Ramachandra-Rao & Rajagopalan (1970), Gupta & Chattopadhyay (1979), Gupta & Paul (1985, 1989) from India are available not only attempting to explore the nest associates but also to find out the inter-relationship that exists between birds, their ectoparasites and other nest associates with an ultimate object to find out if these act as vectors of various diseases of man and other animals in which birds might have some role to play.

In this paper, besides describing seven new species belonging to genera *Steatonyssus*, *Neoeucheyla*, *Microcheyla*, *Pronematus*, *Acheles* and *Lasioseius*, the results of studies made by the authors from West Bengal, India are included in summarised form along with other related published information in order to present a consolidated account of the acarine fauna from bird nests in India. In addition to acarine fauna, a list of other arthropods collected by these authors from bird nests also are included so as to present an overall idea of the arthropodan faunal composition in bird nests.

All the types are deposited in the National Collection of the Zoological Survey of India, Calcutta. The entire collection was made by the junior author. All the measurements given in the text are in microns.

The method of collection of bird nests, the extraction of acarines and other arthropods from there and techniques of study

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are the same as in Gupta & Chattopadhyay (1979) and Gupta & Paul (1985).

A total of 67 species of acarines belonging to 44 genera and 32 families are treated here which includes descriptions of seven new species belonging to 6 genera and 5 families. The acarine fauna that occurs in bird nests have been classified into various groups such as: (1) ectoparasites of birds, (2) predators, (3) fungivorous / saprophagous, (4) casual visitors, (5) accidental occurrence and (6) uncertain association and those are discussed here accordingly. In addition to acarines, other arthropods such as insects, spiders, scorpions, pseudoscorpions, isopods, millipeds, and chilopods collected from nests are also listed here.

ACARINES

1. Ectoparasites of birds

This group embraces both mites and ticks and their number is relatively few as they mostly cling upon the body of the host so long the latter is living. Hence, their occurrence in nests might be because of accidental detachment from host body while fluttering wings or might have entered through nest visitors like rats, squirrels, etc. The species belonging to the families Protolichidae, Dermoglyphidae, Macronyssidae, Ixodidae and Argasidae belong to this category.

Fam. MACHRONYSSIDAE

1. Steatonyssus lonchura sp. nov.
(Figs. 1–2)

Female: Idiosoma 688 long, 433 wide, dorsum with 2 shields. Podonotal shield 278, long, 273 wide; opisthonotal shield 328 long, 207 wide. Striation pattern longitudinal on either side of podonotal and opisthonotal shields. Podonotal shield with 9 pairs of setae measuring 28–49 long while the opistionotal shield with 6 pairs of setae, setae on both the shields smooth and pointed. Striation in between podonotal and opisthonotal shields transverse. About 14–15 pairs of setae present on the interscutal membrane on either side of opisthonotal shield, of which 5–7 pairs present laterally on either side of podonotal shield.

Ventrally, sternal shield much shorter than wide (100 wide) with 3 pairs of setae, the posteriormost one being the longest. Shield margin uniformly sclerotized. Maximum width of genital shield 112, 225 long, with a pair of genital setae, placed almost at the lateral margin of the shield. Anal plate 94 long 74 wide; anterior margin straight with a pair of para-anal setae in addition to a postanal. Ventral surface on either side of shield setose. Measurements of legs: I-IV: 491, 471, 498 and 675 respectivly; measurements of tarsi I-IV : 142, 91, 91 and 127; each with a pair of strong claws.

Male : Unknown.

Holotype : ♀, INDIA : WEST BENGAL, Medinipur, ex nest of *Lonchura malacca*, 22. vii. 1987.

Remarks: This species is close to *Steatonyssus flabellifer* Gupta & Paul (1985) but is distinguished by having podonotal shield only slightly longer than broad (much longer than broad in *flabellifer*) and by the presence of 9 pairs of setae on podonotal shield against 10 pairs in *flabellifer*.

2. Steatonyssus flabellifer Gupta & Paul

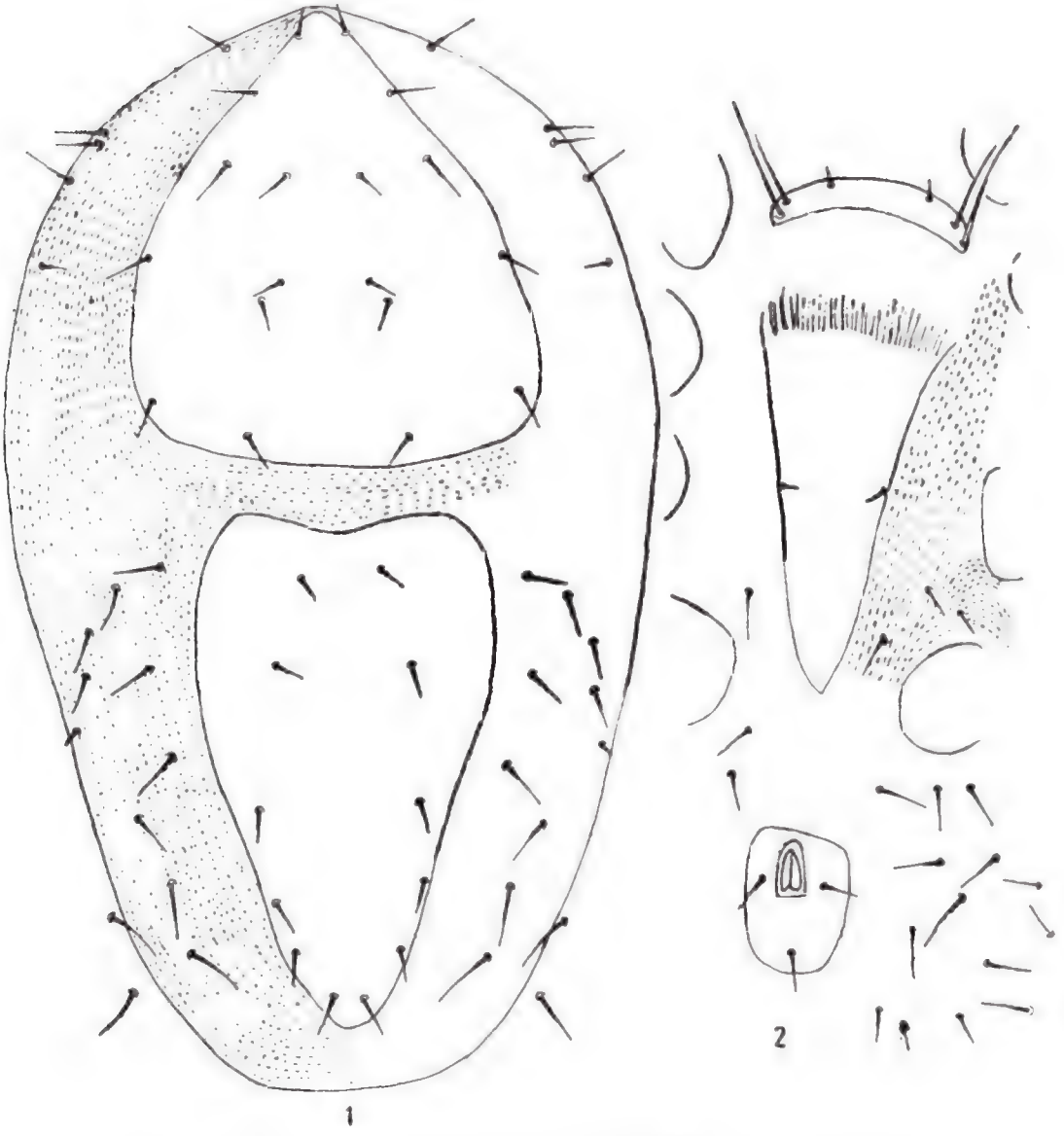
Earlier record of this mite was from nest of *Ploceus philippinus* (Gupta & Paul, 1985).

3. **Ornithonyssus bursa** (Berlese)

All developmental stages of this mite in large numbers were reported from nests of *Corvus splendens* and *Acridotheres tristis* (Ramachandra–Rao & Rajagopalan, 1970). Its other known hosts are *Gallus domesticus*, *Columba livia domestica* and *Passer domesticus*.

4. **Ornithonyssus bacoti** (Hirst)

This is reported from nests of *Lonchura striata* (Gupta & Chattopadhyay, 1979). Being a common rat parasitic mite, its



Figs. 1–2 : *Steatonyssus lonchura* sp. nov. 1. Dorsal surface, 2. Ventral shields.

infestation in nest might be through this mammalian host.

5. Orinthonyssus sp.

A species unrelated to the above two species of this genus was collected from nest of *Passer domesticus* (Gupta & Paul, 1985). Because of being in damaged condition, specific identity could not be definitely established.

6. Pellonyssus sp.

Its report was from nest of *Lonchura malacca, Acridotheres tristis, Corvus splendens* and *Ploceus philippinus* (Ramachandra-Rao & Rajagopalan, 1970).

Fam. PROTOLICHIDAE

7. Protolichus sp.

Its record was from nest of *P. philippinus* (Gupta & Paul, 1985).

Fam. DERMOGLYPHIDAE

8. Pterolichus sp.

A damaged specimen of this genus was reported from nest of *Lonchura malacca.*

Fam. IXODIDAE

9. Haemaphysalis spinigera (Neumann)

This was known from nest of *Lonchura striata* (Gupta & Chattopadhyay, 1979). Being a common ectoparasite of birds, its occurrence in bird nest is not surprising.

10. Haemaphysalis sp.

A nymph of this tick in fully engorged condition was collected from nest of *Ploceus philippinus* (Ramachandra–Rao & Rajagopalan, 1970).

Fam. ARGASIDAE

11. Argas sp.

This tick was reported from nest of *C. splendens* (Ramachandra–Rao & Rajagopalan, 1970). This might have infested nest from the tree where the bird roosts and this tick is available there under bark.

2. PREDATORS

This is a relatively small group among the acarines found in bird nests and is mainly comprised of species belonging to Cheyletidae and Phytoseiidae and their food is mostly the acarid mites (*Acarus* sp., *Tyrophagus* sp.) which occur in bird nests quite abundantly

Fam. CHEYLETIDAE

12. Cheyletus eruditus (Schrank)

A fairly good number of this mite was reported from nests of *Capsychus saularis* and *P. philippinus* (Gupta & Chattopadhyay, 1979).

13. Cheyletus fortis Oudemans

Several specimens of this mite were collected from nest of *P. phillippinus* in West Bengal.

14. Chelacaropsis moorei Baker

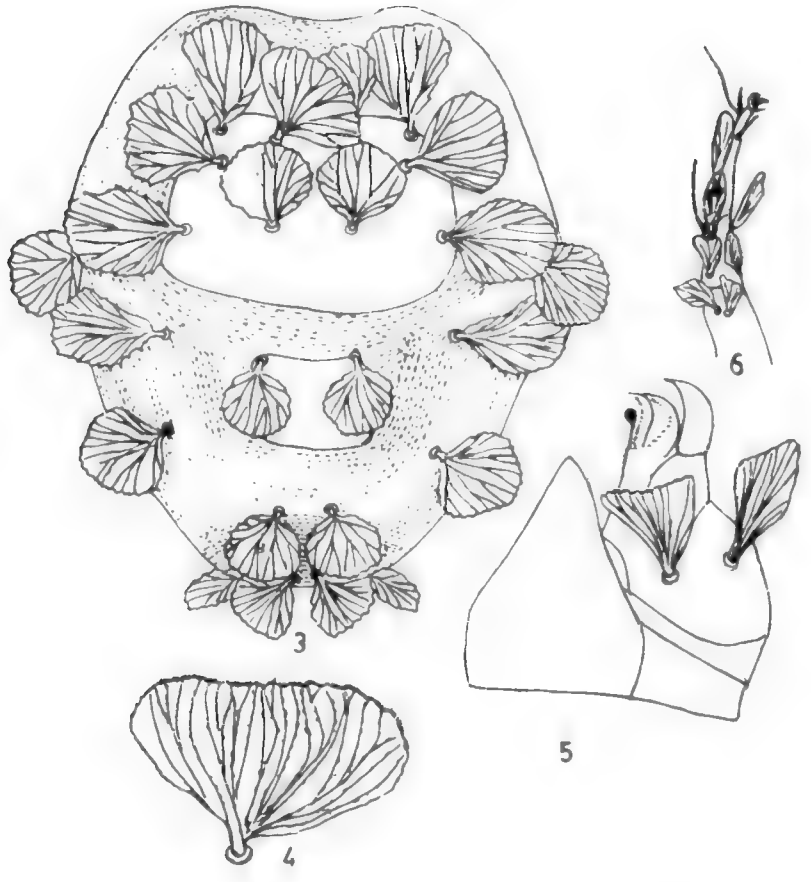
This was reported from nest of *Ploceus manyar flaviceps* and *Lonchura striata* (Gupta & Chattopadhyay, 1979), *P. philippinus* (Gupta & Paul, 1985).

15. Chelatacarus ploceus Gupta & Paul

This was reported from nest of *P. philippinus* (Gupta & Paul, 1985)

16. Neoeucheyla ploceus sp. nov. (Figs. 3–6)

Female : Palp tibia with well developed smooth claw, may possess indistinguishable tooth at the mid-point, a pair of comb-like setae present, each with over 15 combs; sickle-like seta modified into a seta with spatula at the tip, palp femur with one dorsal fan-like seta, 2 ventral fan-like setae



Figs. 3–6 : *Neoeucheyla ploceus* sp. nov. 3. Dorsal surface, 4. Magnified view of idiosomal seta. 5. Gnathosoma (part). 6. Tibia and tarsus I.

and 1 lateral seta, dorsal seta on palp tibia not discernible. Cheliceral stylets long. Transverse arm of peritreme divides stylophore into anterior and posterior sections; each section of peritreme 3–segmented.

Dorsal shield divided into 2 halves, anterior shield with 5 fan-like setae, each seta with about 12–15 longitudinal ribs; ribs further divide; anterior margin broad and wavy; lateral margins also way. Posterior shield with 1 pair of fan-like seta; area between two shields transversely striated; area lateral to anterior shield with longitudinal striation; humeral seta also fan-like; area posterior to posterior shield also transversely striated; 3 pairs of fan-like setae on striated portion of posterior idiosoma; of those one pair small, the other 2 pairs large and of same length. All legs with paired claws. Leg setal formula: femora I-IV : 2: 2: 1: 1; genu I-IV: 2: 3: 2: 2; tibia I-IV: 4: 4: 3: 3; tarsus I-IV: 8 + 1 solenidion: 6: 6: 6. Length of solenidion on tarsus I: 33. Body 510 long, 306 wide.

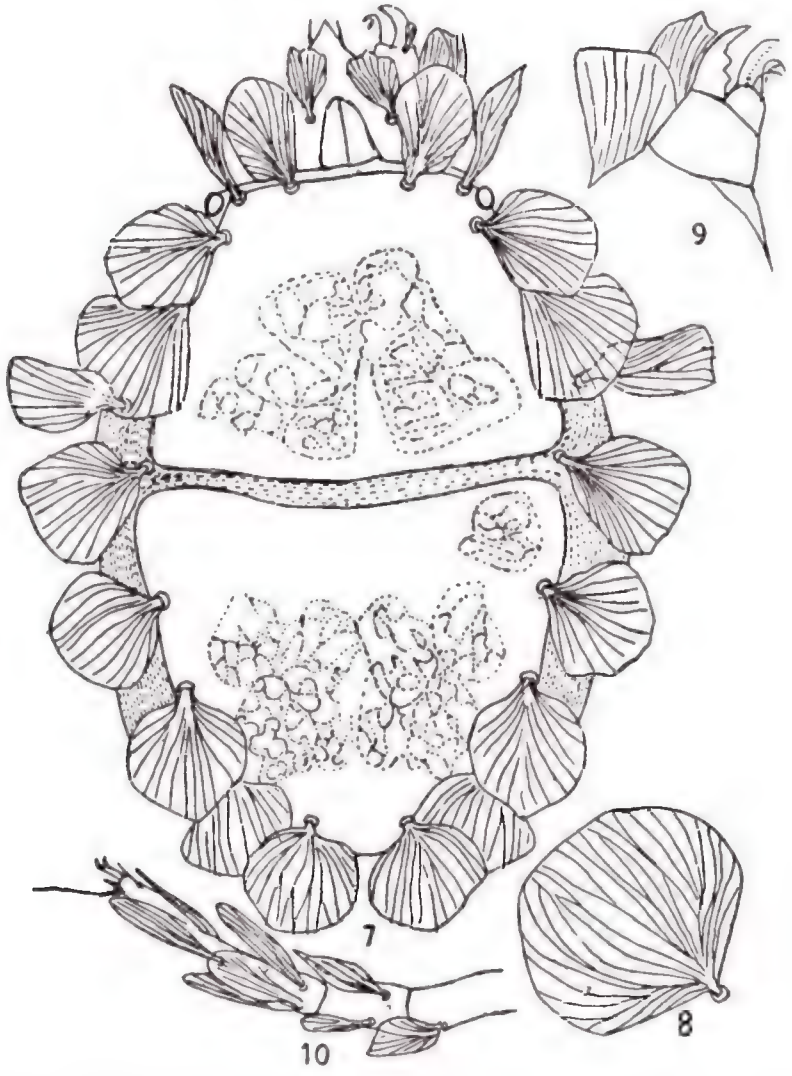
Male : Unknown.

Holotype: ♀, INDIA: West Bengal, Medinipur Jhargram, ex nest of *Ploceus philippinus*, 18. viii. 1985.

Remarks: This genus was earlier unknown from India. Its previous records were from U. S. A. and U. S. S. R. from habitats like grape vines, *Pinus*, tree bugs, etc. This new species is close to *Neoeucheyla panamensis* (Baker, 1949) but is distinguished by the difference in shape of fan-like setae on dorsum and also by palpal chaetotaxy.

17. Microcheyla bengalensis sp. nov. (Figs. 7–10)

Female: Palp tibia with strong claws with 2–3 teeth at the anterior portion of middle half and a large tooth little below it, the palp tarsus with 2 comb-like setae of which one is thicker having over 10 combs and the thinner one with 10–15 combs; sickle-like setae single. Palp femur



Figs. 7–10 : *Microcheyla bengalensis* sp. nov. 7. Dorsal surface. 8. Magnified view of idiosomal seta. 9. Gnathosoma (part). 10. Leg I (part)

with 2 elongated fan-like setae. Palp genu with 2 setae. Peritreme divides the rostrum into the anterior and posterior sections; each half of the peritreme with 2 segments. Rostrum in both sections longitudinally striated. Dorsal plating of idiosoma microtuberculate. Eyes prominent, cornea large, protuberant. Propodosoma wtih 4 pairs of dorsolateral and 3–4 pairs of peculiar shaped dorsomedian in addition to a pair of humerals; 2nd pair of dorosolaterals narrower than others; 5th pair of dorsolaterals present independently between propodosomal and opisthosomal shields. Opisthosoma with 4 pairs of dorsolateral and 3—4 pairs of dorsomedian. The dorsolaterals on opisthosoma wider than those on propodosoma; dorsolateral setae with short peduncle. The dorsomedian setae look clusters of irregularly shaped sclerotic particles strung together on radial branches of hyaline matrix. Striation pattern transverse between propodosomal and hysterosomal plates; margins of plates all along longitudinally striated. Leg chaetotactic formula: tibia I-IV: 5: 5: 4: 4; tarsi I-IV: 8: 8: 7: 7; tarsus w - 49 long; guard seta on tarsus I not discernible, leg I- 288 long, tarsus I- 94 long. Idiosoma 408 long, 306 wide.

Male : Unknown.

Holotype: ♀, INDIA: West Bengal: Medinipur, ex nest of *Ploceus philippinus*, 5. viii. 1986.

Remarks: This genus was earlier unknown from India. This new species is close to *Microcheyla parvula* Volgin (1966) but differs in setal pattern of dorsal shield specially with regard to the number of lateral setae on posterior shield, their structure and in shape of clusterous sclerotic particles as dorsomedian setae.

Fam. PHYTOSEIIDAE

18. Amblyseius largoensis (Muma)

This was known from nest of *Copsychus saularis* and *P. philippinus* (Gupta & Chattopadhyay, 1979 and Gupta & Paul, 1985).

19. Amblyseius herbicolus (Chant)

It was collected from nest of *P. phillippinus*, in West Bengal.

3. FUNGIVOROUS/SAPROPHAGOUS

This is the second largest group of acarines found inside bird nests and is comprised of families like Oribatulidae, Oribatellidae, Camisiidae, Parakalummidae, Acaridae Glycyphagidae, Eupodidae, Tarsonemidae and Fedriziidae. These mites feed upon the excrement, other waste products of the birds or on moulds growing upon these materials. Since the nests having adequate moisture help developing mould due to rapid bacterial and fungal decomposition, a varied groups of mites favouring fungal association will be found in the nest. This will be less in a nest which is of dry type. Whether the nest is wet or dry type will largely determine its faunal composition. These mites also are common in abandoned nests.

Fam. ORIBATULIDAE

20. Scheloribates albialatus Hammer

This was known from nest of *Passer domesticus* and *Streptopelia chinensis* (Gupta & Paul, 1985).

21. Scheloribates sp.

Some damaged specimens of this genus were collected from nests of *Lonchura striata* and *Passer domesticus* (Gupta & Chattopadhyay, 1979).

22. Zygoribatula sp.

It was collected from nest of *Prinia inornata* in West Bengal.

Fam. ORIBATELLIDAE

23. Paralamellobates schoutedeni (Balogh)

It was collected from nest of *Prinia inornata* in West Bengal.

Fam. CAMISIIDAE

24. Platynothrus sp.

It was collected from nest of *Lonchura malacca* in West Bengal.

Fam. PARAKALUMMIDAE

25. Protokalumma sp.

Its report was from nest of *Streptopelia chinensis* (Gupta & Paul, 1985).

Fam. ACARDIAE

26. Acarus sp.

Several specimens of this mite were collected from nests of *P. m. flaviceps*, *P. philippinus* and *P. inornata*. However, the majority of those were either in nymphal forms or were in hypopial stage and that prevented determining their specific identities.

27. Rhizoglyphus sp.

A hypopial stage of this mite was collected from nest of *P. philippinus* from West Bengal.

28. Tyrophagus putrescentiae (Schrank)

A good number of this mite was reported from nests of *C. saularis*, *P. m. flaviceps* and *L. striata* in West Bengal (Gupta & Chattopadhyay, 1979); and from nest of *P. philippinus*.

Fam. GLYCYPHAGIDAE

29. Glycyphagus domesticus (DeGeer)

It was recorded from nest of *Passer domesticus* (Gupta & Paul, 1985). It is common on dampy houses.

30. Lepidoglyphus destructor (Schrank)

A single specimen was collected from nest of *Passer domesticus* (Gupta & Paul, 1985). Its other habitats are bumble bee nests, rodent nests, stored products and soil.

Fam. EUPODIDAE

31. Eupodes sp.

This family mostly occurs on plants but is also known to be associated with fungus. Several specimens in damaged condition were collected from nests of *P. philippinus*.

Fam. TARSONEMIDAE

32. Tarsonemus sp.

It was collected from nest of *P. philippinus* in West Bengal. Baker *et al.* (1976) and Delfinado (1976) also reported this group from bird nests from U. S. A.

Fam. FEDRIZIIDAE

33. Undet. sp.

Some undetermined spp. of this family were reported from nests of *Corvus splendens* (Ramachandra–Rao & Rajagopalan, 1970).

4. CASUAL VISITORS

This is probably the largest group of acarines found in bird nests but all these do not remain in bird nests at a time or throughout the nesting period. Some appear during nest building stage and infest along with nesting materials, some appear when the nest is well settled and feed upon the excreta of birds and may

enter nests through birds themselves or through insects on whose body the mites remain phoretic and some appear when the nest is deserted and mites feed upon the fungus already developed there.

Fam. TYDEIDAE

34. **Pronematus fleschneri** Baker

It was known from nest of *C. saularis* (Gupta & Chattopadhyay, 1979).

35. **Pronematus bengalensis** Gupta & Paul

The occurrence of this mite was reported from nest of *P. philippinus* (Gupta & Paul, 1985).

36. **Pronematus indiana** Gupta & Paul

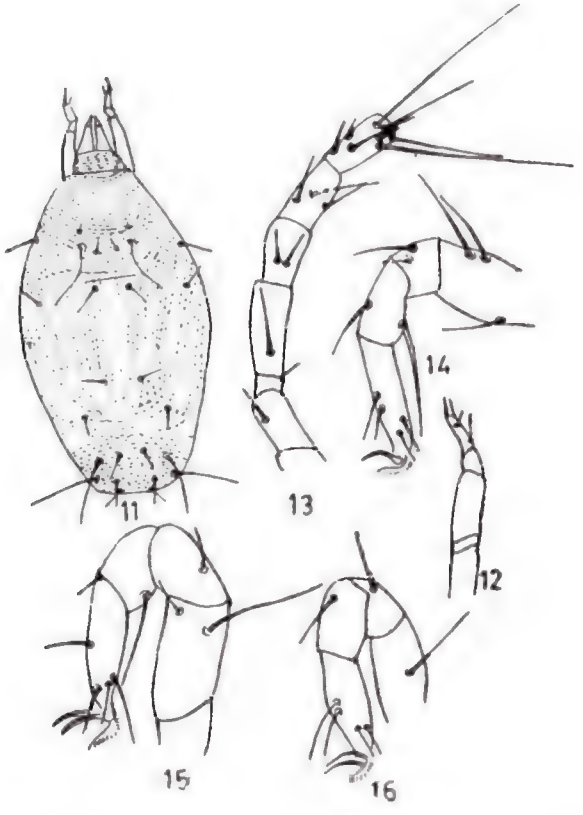
It was reported from nest of *P. dormesticus* (Gupta & Paul, 1985).

37. **Pronematus sp.**

An interesting but damaged specimen was collected from nest of *P. philippinus* in West Bengal.

38. **Pronematus saularis** sp. nov. (Figs. 11–16)

Female: Rostrum broad, short, deeply cleft anteriorly, chelae strong, straight. Palpal setal formula typical for the genus. Distal palpal segment much longer than broad. Propodosonal striae longitudinal



Figs. 11–16 : *Pronematus saularis* sp. nov. 11. Dorsal surface. 12. Palp. 13. Leg I (part). 14. Leg II (part). 15. Leg III (part). 16. Leg IV (part).

with minute fine lobes. Propodosomal sensory setae weakly serrate and more than twice longer than other propodosomal setae; other propodosomal setae lanceolate but not serrate. Lengths of setae P_1, P_2, P_3 being respectively 9, 17 and 24, all finely pubescent, S_1-33 long. Hysterosomal striae longitudinal between setae D2. Dorsal setae of almost similar length, slightly longer than propodosomal setae. Setae L_2, L_3 longer being 56 and 42 long respectively. Ventrally all setae short and of similar length and appear to be plumose. Tarsus I slightly shorter than tibia I (22:18); among the 4 pairs of terminal setae 2 pairs being shorter, all being longer than segment; solenidion broader at base and gradually tapering at tip, being placed at the anterior margin of the segment; other leg setae normal. Length of body 280, width 130.

Male : Unknown.

Holotype : ♀, INDIA : WEST BENGAL, Medinipur, ex nest of *Ploceus philippinus*, 15. vii. 1984.

Remarks: It differs from *P. bengalensis* Gupta & Paul (1985) in striation pattern of propodosomal region and in relative length of D_4, D_5, L_3 and L_4.

Fam. CUNAXIDAE

39. Neocunaxoides biswasi Gupta & Chattopadhyay

It was reported from nest of *C. saularis* (Gupta & Chattopadhyay, 1979).

40. Cunaxa capreolus (Berlese)

This is widely distributed species and its report from bird nest is Gupta & Paul (1985) in nest of *P. philippinus.*

41. Cunaxa setirostris (Hermann)

Its report was from nest of *P. philippinus* (Gupta & Paul, 1985).

42. Cunaxa prinia Gupta & Paul

It was recorded from nest of *P. inornata* (Gupta & Paul, 1985).

43. Neocunaxoides sp.

A damaged specimen was collected from nest of *L. malacca* in West Bengal.

Fam. STIGMAEIDAE

44. Cheylostigmaeus midnapurensis Gupta & Paul

It was known from nest of *Orthotomus sutorius* (Gupta & Paul, 1985).

45. Stigmaeus woodi Gupta & Paul

The report of this mite was from nest of *Streptopelia chinensis* (Gupta & Paul, 1985).

46. Agistemus prinia Gupta & Paul

Its report was from nest of *P. inornata* (Gupta & Paul, 1985).

Fam. BDELLIDAE

47. Spinibdella atyeoi Gupta & Paul

The occurrence of this species was reported from nest of *P. inornata* (Gupta & Paul, 1985).

48. Bdella bakeri Gupta & Paul

Its report is from nest of *S. chinensis* (Gupta & Paul, 1985).

Fam. ERYTHRAEIDAE

49. Undet. sp.

Several specimens of this family were collected from nests of *L. malacca, P. domesticus* and *S. chinensis.* Probably they infest nests through insects on whose body it remains attached.

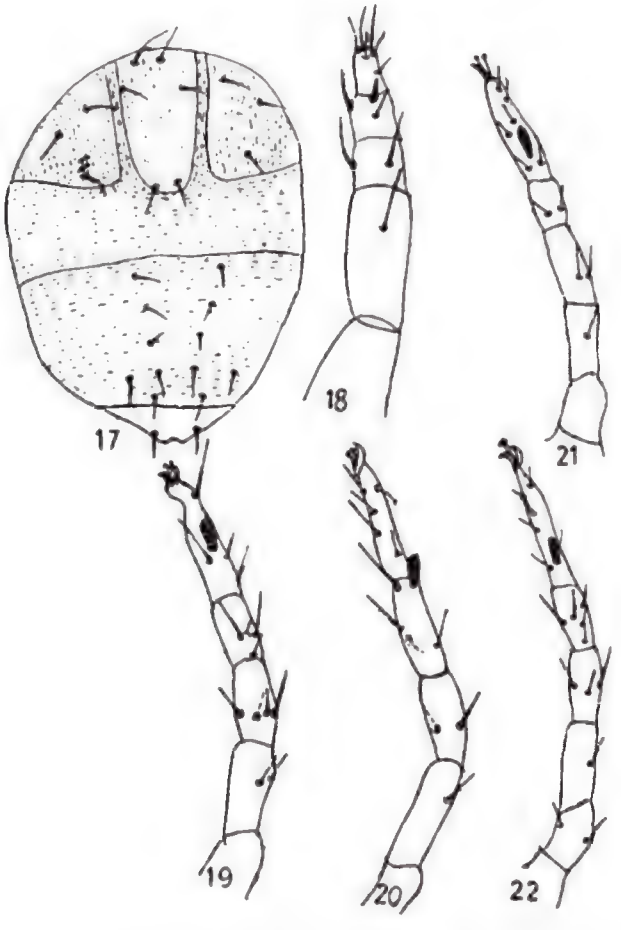
Fam. RAPHIGNATHIDAE

50. Acheles inornata sp. nov. (Figs. 17–22)

Female: Idiosoma 247 long, 190 wide. Propodosoma covered with 3 plates, the median plate rounded posteriorly with 3 pairs of setae; the posterior one is the shortest and the other two of same length. The median and lateral two plates both punctate. The lateral plates each with 3 pairs of setae. The area between lateral and median plates with longitudinal striation while the area posterior to this plate with transverse striation. Setae on lateral plates simple and of same length. Hysterosoma covered with single shield, also punctate, with 6 pairs of setae, 2nd and 3rd pairs almost of same length; 6th pair being closer; length of setae shorter than distance between their bases. One pair of setae present on either side of terminal anal slit. Dorsal setae not on tubercles.

Ventral: Ventrally the genital opening slit-like, 2 setae present on each side.

Gnathosoma : Palp reaches middle of tibia I, claw on penultimate segment weakly developed. Tarsus with 4 thick blunt



Figs. 17–22 : *Acheles inornata* sp. nov. 17. Dorsal surface. 18. Palp. 19. Leg I. 20. Leg II. 21. Leg III. 22. Leg IV.

setae. Peritreme enters anetrior to partly fused chelicerae.

Legs : Measurements of legs as I-224, II-224, III-190, IV- 201. All tarsi end in a pair of claws, empodium ends with tenent hairs.

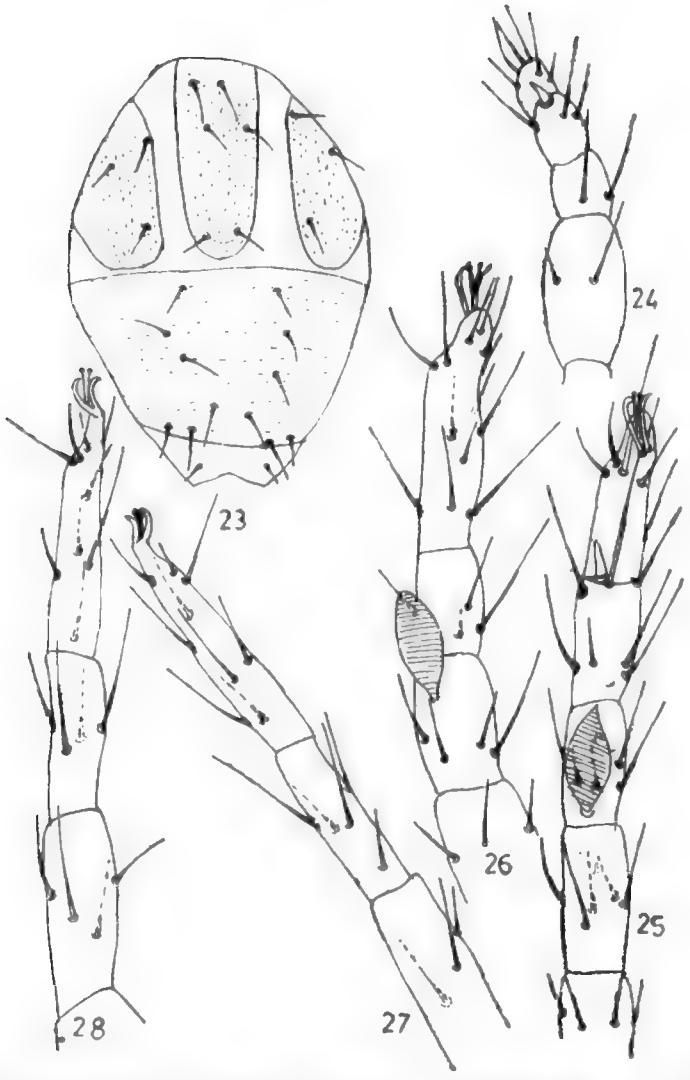
Male: Unknown.

Holotype : ♀, INDIA: WEST BENGAL: Medinipur, from nest of *Prinia inornata*, 4.vi.1986.

Remarks: This new species is distinguished from *Acheles aetheiopica* Meyer & Ryke (1959) by shape of dorsal propodosomal plates and by leg chaetotaxy.

51. Acheles pycnonotus sp. nov. (Figs. 23–28)

Female: Idiosoma 336 long (from posterior



Figs. 23–28. *Acheles pycnonotus* sp. nov. 23. Dorsal surface. 24. Palp. 25. Leg I. 26. Leg II. 27. Leg III. 28. Leg IV.

tip of body to anterior tip of gnathosoma), 174 wide. Propodosoma with 3 plates, 2 lateral and 1 median. The latter with 3 pairs of setae, anteriormost one being the longest. The striation pattern is obscure between median and lateral plates.

Hysterosoma: It is covered with single shield bearing 6 pairs of setae; the first pair being widely apart while the 4th pair being the closest. One pair of setae present terminally at the anal region.

Venter: Genital opening as terminal slit.

Gnathosoma: It reaches upto base of tibia I. Palp tibia bears well developed claws, palp tarsus with a tuft of hairs numbering at least 4. Peritreme enters at the base of fused chelicerae.

Legs: Length of legs: I- 225, II- 204, III- 204, IV- 255. Femur of leg I and II bears a leaf-like sensory organ. Base of tarsus I also bears a thick solenidion. Tarsus ends in a pair of claws and empodium ends in a pair of tenent hairs.

Male: Unknown.

Holotype ♀, INDIA : WEST BENGAL: Medinipur, from nest of *Pycnonotus cafer*, 12. vii. 1984.

Remarks: This new species differs from *Acheles meyerae* Gupta & Paul (1985) in the shape of median plate and in shape of sensory organs in legs I and II.

52. Acheles meyerae Gupta & Paul

It was known from nest of *Prinia inornata* (Gupta & Paul, 1985).

Fam. ASCIDAE

53. Asca pseudospicata Bhattacharyya

Its records are known from *L. striata* (Gupta & Chattopadhyay, 1979) and *P. philippinus* (Gupta & Paul, 1985).

54. Lasioseius malacca sp. nov. (Figs. 29–32)

Female: Length of body 612 long, 280 wide. Dorsal shield 423 long, 229 wide, reticulate with 22 pairs of setae; only 3 pairs of setae present on J series, all being short; other setae on lateral series long; some appear to be finely serrate; 2 pairs of setae on interscutal membrane lateral to shield. Endopodal plate well sclerotized. Sternal shield 91 long, 86 wide, smooth with 3 pairs of sternal setae, metasternal plates with setae distinct. Genital shield 67 wide with a piar of setae. Ventrianal shield 134 long, 174 wide, reticulate with 6 pairs of preanal setae, in addition to para-anal and postanal setae; 2 pairs of metapodal plates present. Peritrematal plate fused anteriorly to exopodal plate. Peritreme extends anteriorly upto j_1 and then curves inwards. Only one pair of setae discernible on the membrane around ventrianal shield. Fixed digit of chlicera with many teeth, that on movable digit not discernible. Macrosetae on leg IV: genu- 51, tibia- 30, basitarsus- 51, distitarsus- 76.

Male: The dorsal setal pattern same as in female. Plates on ventral surface as figured.

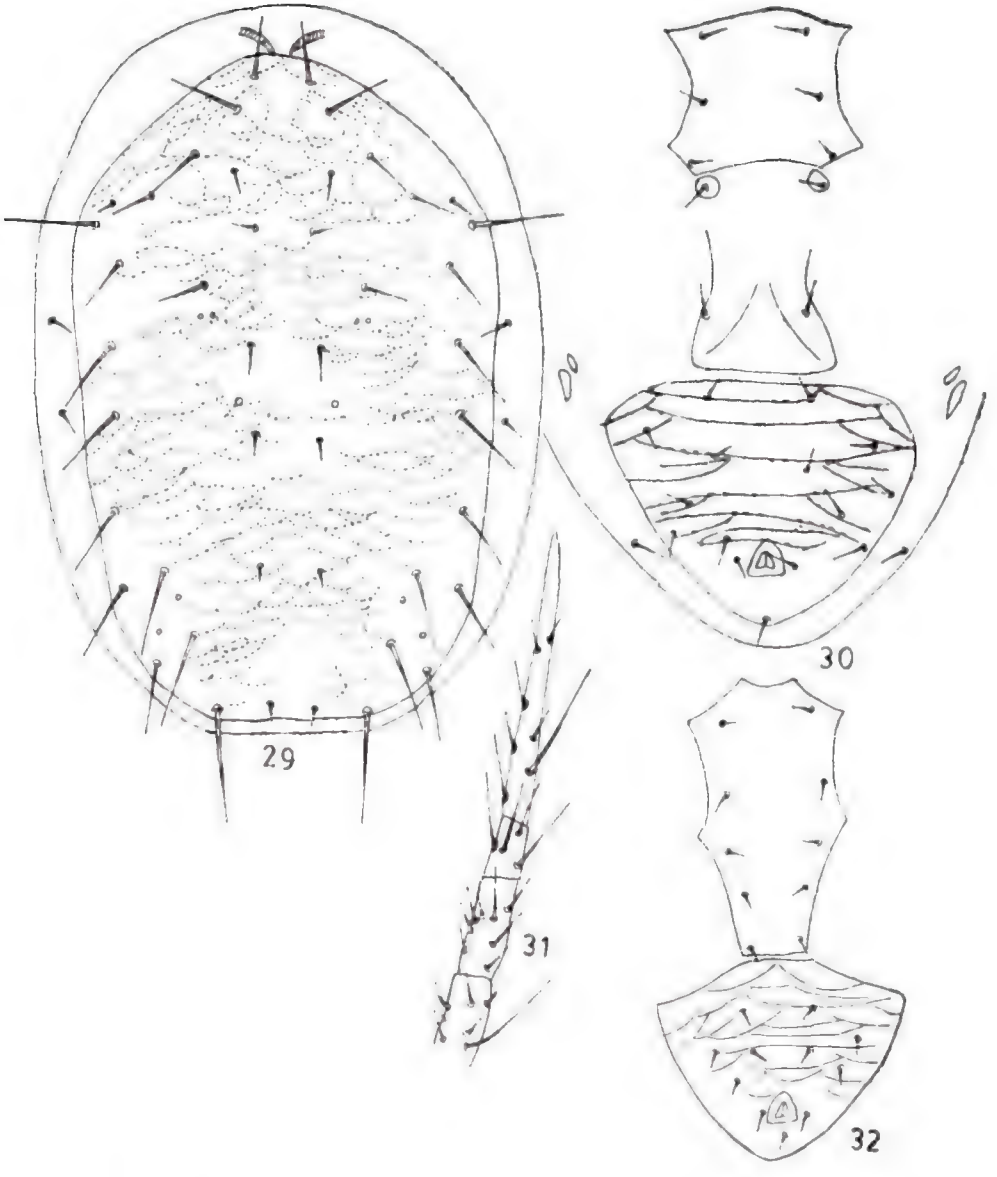
Holotype: ♀, INDIA: WEST BENGAL, Medinipur, ex nest of *Lonchura malacca*. 5. xi. 1987. **Paratype**: 1 ♂, data same as for holotype.

Remarks: This differs from *Lasioseius berlesei* (Oudemans) in shape of ventrianal shield and in relative length of prolateral setae on dorsal shield.

Fam. AMEROSEIIDAE

55. Kleemania bengalensis Bhattacharyya

Its report was from nest of *C. saularis* and *P. m. flaviceps* (Gupta & Chattopadhyay, 1979).



Figs. 29–32 : *Lasioseius malacca* sp. nov. 29. Dorsal shield (♀). 30 Ventral shields (♀). 31. Leg IV. 32. Venral shields (♂).

56. Ameroseius sp.

It was reported from nest of *P. m. flaviceps* (Gupta & Chattopadhyay, 1979).

Fam. DERMANYSSIDAE

57. Hypoaspis vacuua (Michael)

It was collected from nest of *C. saularis* (Gupta & Chattopadhyay, 1979).

58. Hypoaspis acuta (Michael)

Its collection record was from nest of *C. saularis* (Gupta & Paul, 1979). It has been collected from ant nest also.

59. Ololaelaps sp. nr. *veneta* Berlese

It was reported from nest of *P. m. flaviceps* (Gupta & Chattopadhyay, 1979). It is also available in nests of other animals.

5. ACCIDENTAL OCCURRENCE

The occurrence of these mites in bird nests is rather interesting in the sense that these are commonly inhabitants of some other habitats like plants, dust, etc., and their occurrence in bird nest is purely accidental may be due to contamination through nesting materials.

Fam. TETRANYCHIDAE

60. Oligonychus indicus (Hirst)

This was collected from nest of *L. malacca* in West Bengal.

61. Eotetranychus sp.

It was recorded from nest of *P. philippinus* (Gupta & Paul, 1985).

Fam. TENUIPALPIDAE

62. Brevipalpus phoneicis (Geij)

Its report is from nest of *P. philippinus* from West Bengal.

Fam. PYROGLYPHIDAE

63. Dermatophagoides sp.

A Single specimen of this mite was collected from nest of *P. inornata*. Philips and Dindal (1979) also reported dust mite from bird nest.

UNCERTAIN ASSOCIATION

Fam. EPIDERMOPTIDAE

64. Undet. sp.

An undet. specimen of this family was reported from nest of *P. philippinus* (Ramachandra–Rao & Rajagopalan, 1970).

Fam. SMARIDIIDAE

65. Undet. sp.

Report of undet. specimen of this family is available from nest of *C. splendens* (Ramachandra–Rao & Rajagopalan, 1970).

HYDRACHNELLAE

66. Undet. sp.

Report of undet. sp. of this group is available from nest of *C. splendens* (Ramachandra–Rao & Rajagopalan, 1970).

UROPODINA

67. Undet. sp.

Several specimens of this group were recorded from nests of *P. domesticus* and *A. tristis* (Ramachandra-Rao & Rajagopalan, 1970).

OTHER ARTHROPODS

Apart from acarines, a large number of other arthropods were also collected from bird nests and a brief synopsis is given below:

INSECTA: Thysanura (Lepismatidae), Collembola (Entomobryidae), Orthoptera (Gryllidae), Dermaptera (Carcinophoridae), Dictyoptera (Blattidae), Embioptera, Isoptera, Neuroptera, Psocoptera (Liposcelidae, Ectopsocidae, Trogiidae, Pachytroctidae), Anoplura, Hemiptera (Pseudococcidae, Anthocoridae, Aphididae), Lepidoptera (Noctuidae), Diptera (Psychodidae,

Culicidae, Chloropidae, Muscidae), Hymenoptera (Formicidae), Coleoptera (Carabidae, Anthicidae, Staphylinidae, Tenebrionidae, Dermestidae, Silvanidae, Curculionidae).

ARANEAE : Araneidae, Theridiidae, Salticidae, Zodariidae, Onopidae, Scytodiidae, Gnaphosidae, Clubionidae, Pholcidae).

SCORPIONES : Scorpions

PSEUDOSCORPIONES : Pseudoscorpions

ISOPODA :

MILLIPEDE :

CHILOPODA : Pollyxenidae

ACKNOWLEDGEMENTS

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ADDITIONAL RECORDS OF MOSQUITOES OF GOA

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So far a total of 49 species of mosquitoes were known from Goa. During an extensive survey conducted between September 1986 and June 1987, a total of 77 species were collected, of which 40 were recorded for the first time. This increases the number of species known in the state to 89, which comprises 26 species belonging to the genus *Anopheles*, 19 to *Aedes*, 29 to *Culex*, 6 to *Uranotaenia*, 4 to *Mansonia* and 1 each to *Orthopodomyia*, *Toxorhynchites*, *Armigeres*, *Heizmannia* and *Malaya*.

***Aedes lugubris* was recorded for the first time from the west coast of Indian main land while *Aedes krombeini* from the west coast of India. Immatures of 9 species viz., *Aedes annulirostris*, *Ae. reginae*, *Ae. aureostriatus* var. *kanaranus*, *Ae. niveus* group, *Culex khazani*, *Cx. minutissimus*, *Heizmannia viridis*, *Orthopodomyia flavicosta* and *Uranotaenia bicolor* were collected from tree holes.**

(*Key words* : new records, mosquitos, Goa)

The state of Goa is an important tourist resort both for Indians and foreigners. In the recent past, this state has experienced small outbreaks of mosquito-borne diseases like Malaria, Japanese encephalitis, Dengue etc. (Choudhary *et al.*, 1983; Mohan-Rao *et al.*, 1983; Narasimhan & Khamre, 1987; Directorate of Health Services: personal communication). During a preliminary survey in 1983, as many as 49 species of mosquitoes were recorded from Goa and their relative abundance was reported (Kulkarni *et al.* 1986). A subsequent study conducted between September 1986 and June 1987 revealed the existence of 40 additional species. This communication presents data on these additional species recorded from the state.

Adults and immature stages of mosquitoes were collected from 108 localities in Goa, situated in the coastal belt in the west, intermediate plateau region in the middle and hilly forested terrain in the east. They were collected by using standard methods. Adults were collected in and around cattle sheds or while biting on cattle or man during dusk (18.00 h to 20.00 h). During the day (8.00 h to 10.00 h) the resting adults were collected from cattle sheds, human dwellings, among bushes, along the stream beds, pit shelters etc. Larvae and pupae were collected from their breeding habitats such as ground pools, ponds, rock pools, paddy fields, tree holes, plant containers, domestic containers etc. They were reared upto adults in the laboratory. All the adults were aneasthetised and identified following the keys by Christophers (1933), Barraud (1934), Reinert (1973) and Peyton (1977). For the present taxonomical status of various species, reference was made to the catalogue by Knight & Stone (1977) and other recent relevant publications (Tewari *et al.*, 1987). Data on the collection records were fed and stored in a personal computer using a Data base Management System. Topographical and climatological features of the State have been described earlier (Borcar *et al.*, 1967; Choudhary *et al.*, 1983).

TABLE 1. Additional records of mosquito species from Goa.

Sl no.	Species	Collected from			
		Cattle sheds	Human dwellings	Out-doors	Larvae/ pupae
1.	*Anopheles* (*Ano.*) *niguerrimus* Giles, 1900	+	—	—	—
2.	*Aedes* (*Aed.*) *uniformis* (Theobald, 1910)	—	—	+	—
3.	*Ae.* (*Aediomorphus*) *piperselatus* (Giles, 1902)	+	—	—	—
4.	*Ae.* (*Adm.*) *vexana vexans* (Neigen, 1830)	+	—	—	—
5.	*Ae.* (*Adm.*) *trimaculatus* (Theobald, 1905)	+	—	+	—
6.	*Ae.* (*Christophersiomyia*) *annulirostris* (Theobald, 1905)	+	—	—	+
7.	*Ae.* (*Diceromyia*) *reginae* Edwards, 1922	—	—	—	+
8.	*Ae.* (*Finlaya*) *aureostriatus* var. *kanaranus* (Barraud, 1924)	—	—	—	+
9.	*Ae.* (*Fin.*) *niveus* group	+	—	+	+
10.	*Ae.* (*Fin.*) *pseudotaeniatus* (Giles, 1901)	—	+	—	+
11.	*Ae.* (*Verrallina*) *lugubris* Barraud, 1928	—	—	+	—
12.	*Ae.* (*Neomelaniconion*) *lineatopennis* (Ludlow, 1905)	—	—	—	+
13.	*Ae.* (*Stegomyia*) *krombeini* Huang, 1975	—	—	—	+
14.	*Ae.* (*Stg.*) *w-albus* (Theobald, 1905)	—	—	+	—
15.	*Culex* (*Culex*) *barraudi* Edwards, 1922	+	—	—	—
16.	*Cx.* (*Cux.*) *mimulus* Edwards, 1915	—	—	+	—
17.	*Cx.* (*Cux.*) *sinensis* Theobald, 1903	+	+	—	—
18.	*Cx.* (*Cux.*) *sitiens* Wiedemann, 1828	+	+	+	—
19.	*Cx.* (*Cux.*) *univittatus* Theobald, 1901	+	—	—	—
20.	*Cx.* (*Culiciomyia*) *fragilis* Ludlow, 1903	—	—	—	+
21.	*Cx.* (*Cui.*) *nigropunctatus* Edwards, 1926	—	—	+	+
22.	*Cx.* (*Eumelanomyia*) *brevipalpis* (Giles, 1902)	—	+	+	+
23.	*Cx.* (*Eum.*) *castrensis* Edwards, 1922	—	—	+	—
24.	*Cx.* (*Eum.*) *khazani* Edwards, 1922	—	—	+	+
25.	*Cx.* (*Eum.*) *malayi* (Leicester, 1908)	+	—	+	+
26.	*Cx.* (*Lophoceraomyia*) *mammilifer* (Leicester, 1908)	—	—	+	—
27.	*Cx.* (*Lop.*) *minor* (Leicester, 1908)	+	—	+	+
28.	*Cx.* (*Lop.*) *minutissimus* (Theobald, 1907)	+	—	+	+
29.	*Cx.* (*Lop.*) *uniformis* (Theobald, 1905)	—	—	+	—
30.	*Cx.* (*Lutzia*) *fuscanus* Wiedemann, 1820	—	—	+	+
31.	*Heizmannia* (*Hez.*) *viridis* Barraud, 1929	—	—	+	+
32.	*Malaya genurostris* Leicester, 1908	+	—	—	—
33.	*Orthopodomyia flavicosta* Barraud, 1927	—	—	+	+
34.	*Uranotaenia* (*Pseudoficalbia*) *atra* Theobald, 1905	—	—	+	—
35.	*Ur.* (*Pfc.*) *bicolor* Leicester, 1908	—	—	+	+
36.	*Ur.* (*Pfc.*) *obscura* Edwards, 1915	—	—	+	—
37.	*Ur.* (*Pfc.*) *recondita* Edwards, 1922	—	—	+	—
38.	*Ur.* (*Pfc.*) *stricklandi* Barraud, 1926	—	—	+	+
39.	*Ur.* (*Ura.*) *campestria* Leicester, 1908	+	—	+	+
40.	*Toxorhynchites* (*Tox.*) *splendens* Wiedemann, 1819)	—	—	—	+

Earlier, the bio-ecological information on 49 species of mosquitoes collected from Goa has been reported (Kulkarni *et al.*, 1986). The data on the additional 40 species collected from different habitats are presented in Table 1. Some other significant observations are as follows:-

Aedes lugubris has been known from the Andaman Islands, Burma and the Malayan peninsula (Knight & Stone, 1977). Recently it was recorded at Pitchavaram near Chidambaram in Tamil Nadu and was found breeding in tree holes in mangrove swamps (Rajagopalan and Bhat, personal communication). During our survey in Goa, a single female specimen was collected at Mapusa close to a mangrove swamp. This record extends the geographic range of the species from Malayan peninsula to as far as the west coast of India. *Ae. krombeini* originally known from Sri Lanka and recently reported from Nilgiri hills of Tamil Nadu (Tewari *et al.*, 1987) has been recorded from the west coast of India for the first time. *Culex barraudi* and *Malaya genurostris* which were once considered to be restricted to the higher elevation in the mountanous regions have now been recorded from the coastal region of Goa. The latter mosquito, although does not feed on cattle because of its specialized mouth parts but found resting inside cattle shed, probably hunting for ants to obtain its food. Out of 21 species obtained from larvae and pupae, nine species, viz., *Aedes annulirostris, Ae. reginae, Ae. aureostriatus* var. *kanaranus, Ae. niveus* group, *Culex khazani, Cx. minutissimus, Heizmannia viridis, Orthopodomyia flavicosta* and *Uranotaenia bicolor* were collected from tree holes. With the addition of these 40 species, the number of species recorded from Goa has risen to 89, comprising 26 of *Anopheles*, 19 of *Aedes*, 1 of *Armigeres*, 29 of *Culex*, 1 of *Heizmannia*, 1 of *Malaya*, 4 of *Mansonia*, 1 of *Toxorhynchites* and 6 of *Uranotaenia*.

In view of recent outbreaks of Japanese encephalitis, dengue and the escalation of malaria, information on the mosquito fauna of the state is of considerable significance.

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FORAGING INTENSITY OF INSECTS AND NECTAR OF WILD CHERRY, *PRUNUS PUDDUM* ROXB.

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Nectar sugar concentration of *Prunus puddum* which exceptionally flowers during autumn, was 12.37 to 17.45 per cent. Maximum nectar in the flowers was during morning hours (49.15 μl per flower). Activity of *Apis mellifera* and *A. cerana indica* peaked during 1100 and 1400 h, respectively. An account of diel changes in the nectar is also given. Standing crop of nectar remained high throughout the day revealing possibility of keeping more bee colonies in the experimental area.

(*Key words:* wild cherry, *Prunus puddum*, nectar, foraging insects)

INTRODUCTION

Wild cherry, *Prunus puddum* Roxb. is a perennial tree which grows on stony hill sides at altitudes between 1000-3000 metres above mean sea level in the Himalayas and flowers during autumn when bee forage is scarce. Earlier studies on *P. puddum* revealed that it has honey potential to the extent of 34 kg/100 trees (REDDY & GUPTA, 1987) and that nectar removal at short interval during a day resulted in 120 per cent more nectar secretion in the flowers than in those where it was allowed to accumulate (GUPTA *et al.*, 1990). But the secretion rate in a flower from which nectar is continuously removed by the bees may not be the same as that in a flower in which nectar is artificially removed or is allowed to accumulate (CORBET & DELFOSSE, 1984). In the present study observations have been recorded on the standing crop of nectar in the unprotected flowers of *P. puddum*, since it reflects the relative rates of gain by secretion and loss by reabsorption and/or removal by insects. Observations have been made on the activity of insect visitors on the flowers during different day hours in relation to the standing crop of nectar in the flowers.

MATERIALS AND METHODS

The present studies were carried out around University campus at Nauni (30.33°N latitude, 70.7°E longitude and 1300 metres altitude), Solan, India, during November. Volume and concentration of nectar in the flowers was measured at 0930 and at 2 hour interval till 1730 h. Twenty five flowers were selected at random on three differennt trees for each observation. Nectar was withdrawn from the flowers using standardized microcapillaries. After measuring the volume (μl) of the nectar present in each flower, the sugar concentration was determined with a hand refractometer, Erma, Japan. Dry nectar sugar content was calculated from the volume and concentration of nectar.

Activity of insect visitors was determined per metre square blooming branch per five minutes (replicated 5 times), during 0700 to 1700 h at hourly interval. Average of three days represented the activity of insects during different day hours.

The data were analysed statistically by using factorial rendomized block design.

RESULTS AND DISCUSSION

The volume of nectar per flower was maximum at 0930 h (49.15 μl) and then remained low till 1530 h (Table 1) but non-significantly increased between 1530 and 1730 h. Nectar accumulation was negatively related to temperature ($r = +0.93$) but positively to humidity ($r = +0.88$). The nectar sugar concentration was low at 0930 h but increased up to 1530 h. Nectar concentration showed positive correlation with temperature ($r = +0.89$) but a negative correlation with humidity ($r = -0.82$). Post secretory changes in nectar due to exchange of water molecules with the atmosphere are common (SHUEL, 1959) and more pronounced in flowers having exposed nectaries (PARK, 1929). Increased nectar concentration during the day, due to post secretory changes, also points out that probably negligible amount of nectar is secreted during the day hours which otherwise would have diluted the accumulated nectar. A similar trend of nectar secretion has been reported in flowers of 'dhain' *Woodfordia* which has as much as 126 μl of nectar with 10.65% sugar concentration (MISHRA *et al.*, 1987). This trend is beneficial to the nectarivores as they get higher concentration of nectar due to evaporation than at which it is secreted, thus saving energy required to concentrate it.

Changes in nectar sugar content in a flower indicate whether nectar is being secreted or being removed and/or resorbed. The sugar content of nectar, representing the standing crop, was maximum in the morning but gradually declined till evening with increase in insect activity (Fig. 1). With the decline in insect visits after 1530 h, nectar in the flowers increased. From

TABLE 1. Nectar contents of *Prunus puddum* flowers during different day hours.

Time of sampling	Temperature (°C)	Humidity (%)	Volume of nectar/flower (μl)	Concentration of nectar (%)
0930	13.0	61	49.15	12.37
1130	16.5	56	42.30	13.70
1330	18.5	49	34.95	15.95
1530	20.5	42	26.15	17.45
1730	17.5	54	30.75	17.15

$CD_{(0.05)}$ Nectar volume = 4.06

Nectar concentration = 0.92

Co-efficient of linear correlation (r) between

i) Temperature and volume of nectar = −0.93

ii) Humidity and volume of nectar = +0.88

iii) Temperature and concentration of nectar = +0.89

iv) Humidity and concentration of nectar = −0.82

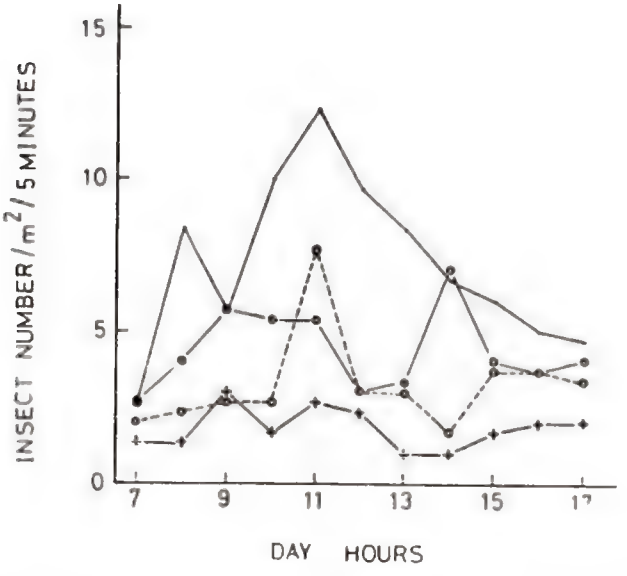

Fig. 1. Activity of honeybees and other insect visitors on *P. puddum* flowers during different day hours.

—. —*A. mellifera*; —o—*A.c. indica*; ---o--- Other Hymenoptera; —+—Other insects

the data it is revealed that on an average 0.5 mg sugar is being removed by insects and/or resorbed by a flower every two hour. The prominent insect visitors were honeybees, *Apis mellifera* and *A. cerana indica* which constituted more than 75 per cent of the total insect visits. Other visitors included *Bombus* sp. and other bees (solitary) as well as some Lepidoptera and Diptera. Honeybees foraged both for nectar and pollen and started foraging early in the morning even when temperature was around 10°C and continued foraging till evening. Peak activity of *A. mellifera* and *A. cerana indica* was at 1100 and 1400 h, respectively (Fig. 1). This implies that the activity of *A. c. indica* peaked when nectar concentration was comparatively higher thus getting higher caloric rewards. Activity of other Hymenoptera also peaked during 1100 h. Reason for such a difference remains to be explained though possibility of existence of inherent flight periodicity has been reported even within colonies of a bee species (MURRELL & NASH, 1981).

P. puddum flowers during autumn when there is dearth of bee flora. Although *Plectranthus* also blooms during this period, which is efficiently used by honeybees (GUPTA *et al.*, 1984), but being erratic in honey flow due to its susceptibility to soil moisture, its importance is limited (SINGH, 1982). The high nectar content despite good bee activity, indicates that *P. puddum* can further be exploited as a nectar source by keeping more colonies.

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A NEW SPECIES AND FIRST RECORD OF BREVIPALPID MITES FROM NORTHERN INDIA

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A new species of phytophagous mite namely *Brevipalpus nangalensis* sp. nov. of the family Tenuipalpidae is described and illustrated. Two other brevipalpid mites are recorded for the first time from northern India.

(*Key words:* new species, first records, brevipalpid mites, India)

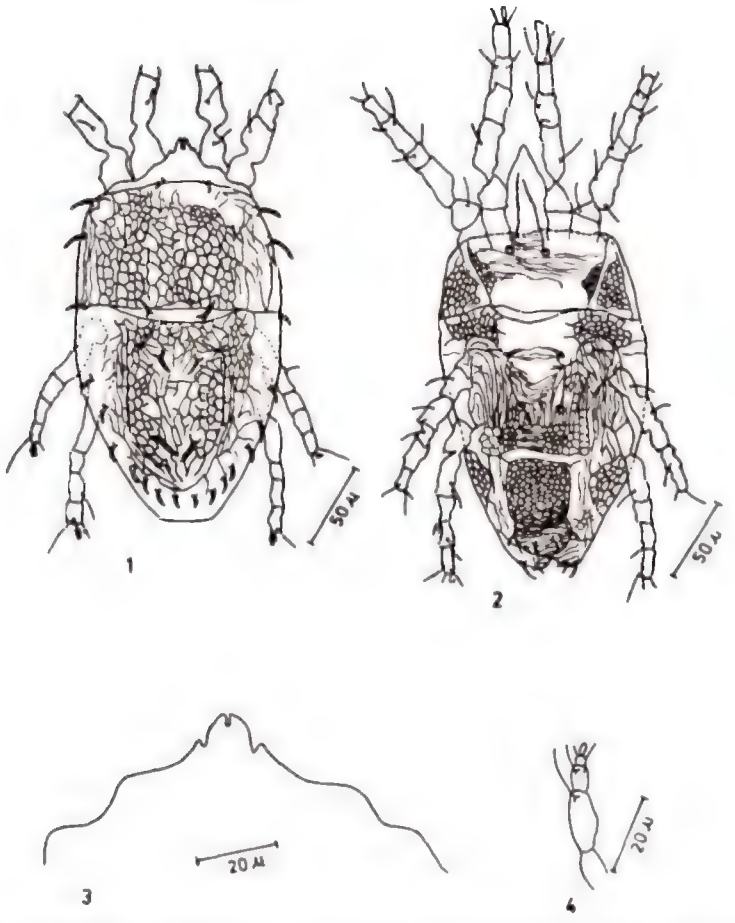
The brevipalpid mites of the family Tenuipalpidae are strictly phytophagous and hence of great economic importance. Of the 205 species known from the world (Meyer, 1979; Ghai and Shenhmar, 1984) only 16 species have been recorded from India (Sadana, 1985). However, no serious attempt has been made to study the brevipalpid mite fauna from northern India. In view of this, extensive survey was made to record the fauna of this region. An examination of the collected material has revealed a new species and two first records which are reported herein.

Brevipalpus nangalensis sp. nov.
(Fig. 1–4)

Female: Body 203[1] long (without rostrum) and 126 wide. Palpus 4 segmented, with one sensory rod and two setae on terminal segment. Rostrum reaching up to base of femur I. Rostral shield with a median and three lateral lobes on each side. Propodosoma with thick walled reticulations mediolaterally. Faint reticulations in the rest of the region except for a few broken striations laterally. Propodosomal setae 3 pairs, lanceolate, measuring 4, 10 and 12 respectively. Eyes one pair on each side Humeral setae one pair, each seta 8 long. Hysterosoma with 2–3 rows of long cells and thick walled reticulations mediolaterally; faint broken reticulations medially; broken striations laterally; with a pair of pores. Dorsocentral setae 3 pairs, slightly lanceolate, measuring 8, 8, and 10 respectively. Dorsolateral setae 7 pairs, lanceolate, measuring 6, 14, 6, 10, 10, 12 and 12 respectively.

Ventrally, propodosoma with reticulations posterior to coxae II; transverse striations anteromedially behind the basis of medioventral propodosomal setae: longitudinal striations on and inner to coxae III and IV. Ventral propodosomal setae one pair, long, each set 32 long. Anterior and posterior medioventral metapodosomal setae one pair each, 6 and 22 long, respectively. Posterior region of metapodosoma close to coxae IV with a few thin and thick reticulations, transverse striations inner to the bases of posterior medioventral metapodosomal setae. Ventral shield reticulated, with one pair of setae, simple, each seta 6 long. Lateral margins of body close to ventral shield with a patch of

1. Measurements in μm.



Figs. 1-4 *Brevipalpus nangalensis* sp. nov: 1. dorsal view of female (legs partially shown). 2. ventral view of female (legs partially shown). 3. Rostral shield. 4. Palp.

reticulations, area in between these patches and ventral and genital shields with striations. Genital shield with transverse broken striations, with two pairs of setae, each seta being simple and 10 long. Anal shield with two pairs of setae, members of inner 6 and outer 8 long.

Legs 4 pairs, segments wrinkled, setae on legs I-IV: coxae 2-2-1-1; trochanters 1-1-1-1; femora 3-4-2-1; genua 3-3-1-1; tibiae 5-5-3-1 and tarsus 3-3-3-3. Tarsus II with two sensory pegs. Dorsal setae on femora I and II not longer than the width of the segment.

Male: Not known

Collection data. **Holotype**: ♀, encircled on slide No. 159, ex. *Jasminum sambac*, 27. ii. 1989, Nangal (Ropar), Coll. Anu Priya, **Paratype**: ♀, on slide No. 159 collection data same as for holotype and 2 ♀ ♀, slide No. 201m, ex *Jasminum sambac*, 15. vi. 1991 Nangal Coll. G. L. Sadana.

Remarks: The present form is distinct in having 7 pairs of dorsolateral hysterosomal setae and is the only one with this type of character being reported in the genus *Brevipalpus*. It is named after the locality of its collection.

Brevipalpus cucurbitae Mohanasundaram, 1982 *Collection data:* 1 ♀, each mounted on slide Nos. 25 and 26, ex. *Psidium guajava,* 27. xi. 1988, P. A. U. (Ludhiana, Coll. Balpreet; 1 ♀ slide No. 85, ex. *Citrus aurantifolia,* 4.i. 1989, P. A. U. (Ludhiana), Coll. Balpreet.

Distribution: India-Tamil Nadu; Punjab.

Remarks: The present form keys out to be *B. cucurbitae.* Earlier it has been recorded from Tamil Nadu on Squash. It is recorded for the first time from Northern India on new host plants i. e., *Psidium guajava* and *Citrus aurantifolia.*

Brevipalpus euphorbiae Mohanasundaram, 1982

Collection data : 1 ♀, Slide No. 103, ex. *Citrus aurantifolia* 15. i. 1989, Hoshiarpur, Coll. Balpreet.

Distribution: India-Tamil Nadu, Punjab.

Remarks: The present form keys out to be *Brevipalpus euphorbiae.* Earlier, it has been recorded from Tamil Nadu on *Croton sp.* It is recorded for the first time from Northern India on a new host plant i. e., *Citrus aurantifolia.*

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The authors are thankful to Dr. H. S. Toor, Professor & Head, Department of Zoology, Punjab Agricultural University, Ludhiana for providing the laboratory facilities.

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ON TWO SPECIES OF *ALEURODICUS* DOUGLAS (ALEURODICINAE : ALEYRODIDAE : HOMOPTERA) FROM INDIA WITH A KEY TO INDIAN SPECIES

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(*Received* 9 *March* 1991)

A new whitefly *Aleurodicus indicus* infesting the leaves of *Polyalthia suberosa* Thw. (Annonaceae) at Kunnathoor, Tamil Nadu, and *Aleurodicus holmesii* (Maskell) on the leaves of *Dimocarpus longon* Lour. (Sapindaceae) at Saklespur, Karnataka, India, are described. A key to the Indian species of *Aleurodicus* is given.

(*Key words :* *Aleurodicus holmesii*, *Aleurodicus indicus*, *Dimocarpus longon*, *Polyalthia suberosa*, Aleurodicinae, Aleyrodidae)

David (1987) described a new species *Aleurodicus philomenae* from *Persea macarantha* (Lauraceae) from Maharashtra, India. This was the first species of *Aleurodicus* Douglas (Aleurodicinae) reported from India. Subsequently David and Selvakumaran (1990) synonymised this with *A. machili* Takahashi. In this paper a new species *A. indicus* collected from *Polyalthia suberosa* is described. *A. holmesii* (Maskell) so far recorded from Sri Lanka, Thailand, Java, New Guinea and West Malaysia has now been collected for the first time from India and redescribed here.

1. Aleurodicus holmesii (Maskell)

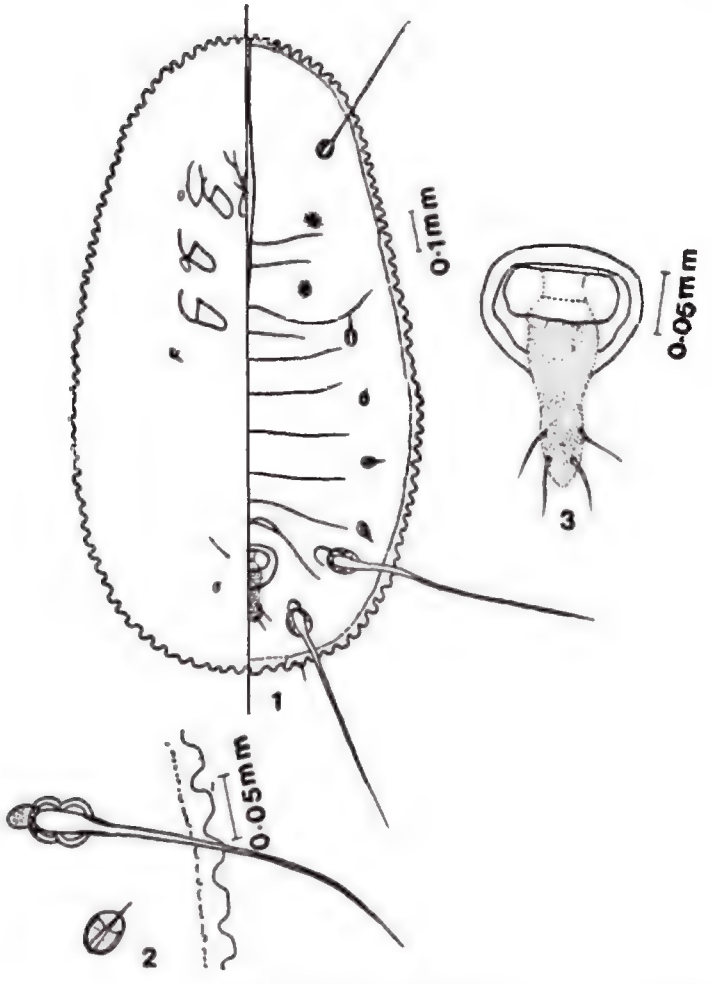
(Figs. 1 to 3)

Pupal case: White, oval, with a copious amount of white cottony secretion - fluffy, waxy and ribbon-like extending upward and outward from the dorsum, white glass-like waxy rods arising from each compound pore and whitish translucent striated wax extending from ventral submargin to leaf. Measures 1.08 - 1.50 mm long and 0.58 - 0.84 mm wide. Found infesting on the lower surface of leaves in groups on veins only.

Margin: Regularly toothed, 3–5 teeth in 0.1 mm. Thoracic and caudal tracheal pores and combs absent; anterior marginal setae not discernible, whereas posterior marginal setae 15 - 22.5 μm long.

Dorsal surface: Seven pairs of subdorsal compound pores - one pair on the cephalus and six pairs on the abdomen - one each on abdominal segments 2 and 4–8; each pore with a pointed spine. The first four pairs of abdominal compound pores and spines are small - 27.5 - 52.5 μm, 12.5 - 25.0 μm, 17.5 - 25.0 μm and 25 - 55 μm long respectively. The cephalic spine is 220-290 μm long. Seventh and eighth abdominal spines are longest, 250 - 370 μm long each. Two pairs of minute submarginal setae-one pair on the anterior and the other on the caudal region evident. Longitudinal moulting suture reaches margin and transverse moulting suture reaches subdorsum. Dorsum devoid of setae. Seventh abdominal segment suture thickened. Two pairs of star-like markings - one pair on prothorax and another on metathorax present.

Vasiform orifice subcordate, wider than long, 107.5 - 130.0 μm wide and 87.5 -



Aleurodicus holmesii (Maskell)
Fig. 1. Pupal case; Fig. 2. Margin with subdorsal spines; Fig. 3. Vasiform orifice.

110.0 μm long; operculum similarly shaped, 75.0 - 97.5 μm wide and 35.0–40.0 μm long; lingula long, setose and excluded, 97.5 - 150.0 μm long with two pairs of setae (25–37.5 and 45.0 - 52.5 μm long respectively) at its tip.

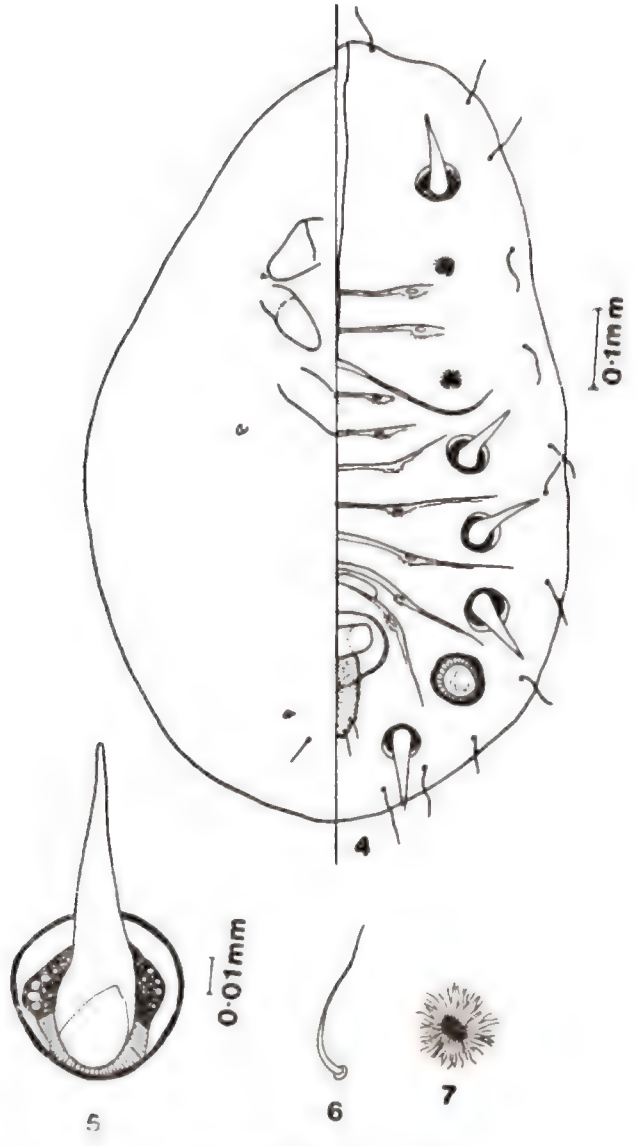
Ventral surface: Paired ventral abdominal setae 40.0 - 57.5 μm long and 62.5 - 65.0 μm apart. Antennae and legs short.

Host: Dimocarpus longon Lour. (Sapindaceae).

Material examined: 12 pupal cases mounted on slides, on *Dimocarpus longon*, Saklespur (Karnataka), 25.i.1990, K. Regu.

2. Aleurodicus indicus sp. nov.
(Figs. 4 – 7)

Pupal case: White, oval, with a copious amount of powdery wax over the pupa case, long wax rods extending from each compound pore, the pupa case rests on a waxy rim, 0.84 - 0.90 mm long and 0.54 - 0.57 mm wide; found on the lower surface of leaves on veins or near veins in groups.



Aleurodicus indicus sp. nov.

Fig. 4. Pupal case; Fig. 5. Subdorsal compound pore with spine; Fig. 6. Submarginal seta; Fig. 7. Star-like marking.

Margin : Entire, thoracic and caudal tracheal pores and combs absent. Anterior and posterior marginal setae not discernible.

Dorsal surface : Six pairs of subdorsal compound pores - one pair on cephalus (50 - 55 μm wide) and five pairs on abdomen- one each an abdominal segments 4 - 8 (45.0 - 52.5 μm, 45.0 - 50.0 μm, 42.5 μm, 57.5 - 60.0 μm and 42.5 - 45.0 μm wide respectively). Seventh abdominal compound pore is the largest. Each compound pore has a stout spine swollen at the base except

seventh abdominal pore. Cephalic spine 75.0 - 80.0 μm long, fourth abdomianal spine 90.0 - 95.0 μm, fifth 97.5 μm, sixth 87.5 - 90.0 μm and eighth 102.5 - 115.0 μm long. Base of each spine is surrounded by numerous small locules. A row of 12 pairs of long submarginal setae - 5 pairs on cephalothorax and 7 pairs on abdomen 35.0 - 52.5 μm long. Submedian pockets present on all segment sutures. Seventh abdominal segment suture thickened. Two pairs of prominent star-like markings - one each on prothorax and metathorax evident.

Vasiform orifice subcordate, wider than long. 105 - 120 μm wide and 87.5 - 92.5 μm long; operculum similarly shaped, 82.5 - 90.0 μm wide and 40.0 - 42.5 μm long; lingula tongue shaped, long, setose, and exposed, 90.0 - 110 μm long with two pairs of setae at its tip 35 μm each long.

Ventral surface : Paired ventral abdominal setae below the vasiform orifice 55 μm long and 62.5 μm apart. Legs and antennae reduced.

Host: Polyalthia suberosa Thw. (Annonaceae)

Material examined : **Holotype :** One pupal case mounted on slide on *Polyalthia suberosa,* Munchirai (Kanyakumari District), 15.xii.1989, K. Regu. **Paratypes** : 11 pupal cases on slides bearing the same details as of holotype and numerous pupal cases in the collections of K. Regu.

This species differs from other known species of *Aleurodicus* in the absence of spine in the sevenths abdominal compound pore.

KEY TO THE INDIAN SPECIES OF THE GENUS *Aleurdicus* douglas 1982.

1. Abdomen with five pairs of compund pores
   –. Abdomen with six pairs of compound pores, posterior two pairs large and each with a long central spine
   ...*holmesii* (Maskell)
2. Submargin with a row of 12 pairs of setae, seventh abdominal compound pore largest and without spine, margin entire, two pairs of star-like structures on the ceplahlothorax
   ...*indicus* sp. nov.
   –. Submarginal setae absent; fourth abdominal compound pore and spine smaller than others, margin crenate, no aster-like markings on the cephalothorax
   ...*machili* Takahashi

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TAXONOMIC STUDIES ON *APHELINUS* (HYMENOPTERA: APHELINIDAE). 5. DESCRIPTION OF A NEW SPECIES AND FURTHER RECORDS OF *A. GOSSYPII*, WITH A NEW SYNONYMY

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(*Received* 24 *March* 1991)

***Aphelinus albipodus*, sp. nov. is described from materials earlier misidentified as *flavipes* in India. This species has also been recorded from the Chad Republic and Paraguay. *A. kashmiriensis* Hayat is placed in synonymy with *A. gossypii* Timberlake, and the species is recorded not only from several Indian states, but also from the Reunion and Guadeloupe Islands.**

(*Key words:* Aphelinidae, *Aphelinus albipodus* sp. nov., *A. gossypii*)

This is the fifth paper in a planned series on the taxonomy of the genus *Aphelinus* Dalman. It deals with two apparently widely distributed species, of which one is described as new. *A. gossypii* Timberlake is already known from India (see Hayat, 1986) and is here recorded from material collected from several States in India as well as from the Reunion and Guadeloupe Islands. *A. albipodus,* sp. nov. is described for material earlier misidentified in India as *flavipes* by Hayat (1972) and Ramaseshiah & Dharmadhikari (1969). This species has also proved to be widely distributed, being recorded here from India, the Chad Republic and Paraguay. Both the species appear to be parasitoids mainly on *Aphis gossypii,* though several other aphid species are also parasitized, and may eventually prove to be of use in the control of this aphid.

Aphelinus albipodus, sp. nov.
(Figs 1–4)

[*Aphelinus flavipes* (Foerster): Ramaseshiah & Dharmadhikari, 1969: 158. Hayat, 1972: 52, 57. Misidentification.]

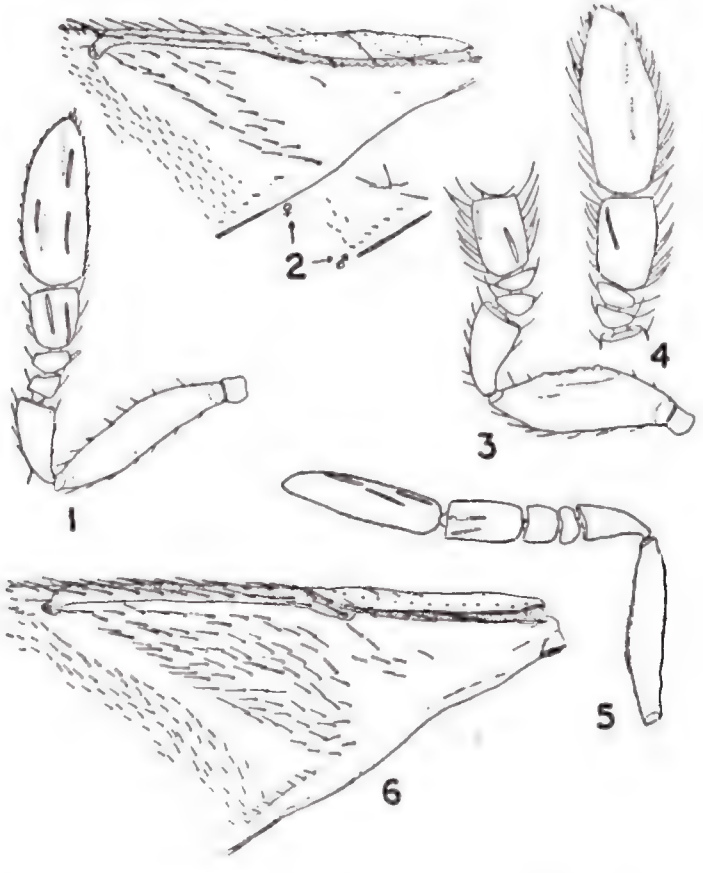
Female: Length, 0.82 - 1.06 mm (Holotype, 0.97 mm). Head and thorax dark brown to nearly black (critical point dried specimens appear brown), gaster brown to dark brown with base (terga I and part of II or tergum I) yellow; third valvulae brown; antennae pale yellow to nearly white, scape and clava lightly infuscate brown in some specimens; wings hyaline, forewing sometimes with a very faint infumation below marginal; legs white to pale yellow, with middle and hind-coxae except apices, dark brown; middle coxae sometimes brown only at base; forecoxae usually yellow to pale brown at base; tibiae, especially the hind-pair, rarely pale brown; last tarsal segments brown.

Head dorsum (occiput perpendicular) slightly more than 2 × as wide as long (24.5–30.5: 11–13), rarely 2.5 × as wide as long; frontovertex, at level of front-ocellus, clearly less than half of head width (10.5–13.5 : 24.5–30.5), and usually very slightly longer than wide (10–13 : 10.5–13.5); ocellar triangle with apical angle obtuse, each lateral ocellus separated from eye margin by about one ocellus diameter and

by about half the diameter of an ocellus from occipital margin; eyes setose; fronto-vertex with dark brown setae of which two pairs at occipital margin are longer as in most other species of the genus.

Antenna (Fig. 1). Scape 4.5–5× as long as wide; pedicel (ventral length) slightly less than 2 × of width; F1 with ventral margin longer than dorsal margin; F2 broader than long; F3 quadrate to a little longer than broad. Relative dimensions: length (width): scape, 35–38.5 (7–8.5); pedicel, 14–15 (8–8.75); F3, 9.5–10.5 (9–9.5); clava, 30–34 (11.5–12).

Thorax normal for the genus in sculpture and setation; mid-lobe of mesoscutum with two pairs of primary setae and 30–40 smaller setae. Forewing (Fig. 2) slightly more than 2 × as long as wide (44.5–54 : 18.5–23.5); costal cell slightly longer than marginal vein and with two lines of setae on ventral surface; basal cell bare, rarely with one or two setae; linea calva at least partly closed posteriorly by setae, and proximally with one complete and 2–3 incomplete lines of setae (27–37 setae); smaller specimens (from Chad and Paraguay) with 19–22 setae.



Figs. 1–6. (1–4) *Aphelinus albipodus*, sp. nov. : 1. Antenna, female; 2. Part of forewing of female, and end of linea calva of male fore wing; 3. Antenna excluding clava, male; 4. Flagellum, male. (5, 6) *A. abdominalis* (Dalman): 5. Antenna, male; 6. Part of forewing, female. Figs. 5 and 6 from British specimens (coll. M. Hayat).

Gaster, depending on the state of preservation, slightly longer than thorax to as long as head plus thorax; ovipositor not or very slightly exserted. [Relative lengths: ovipositor = second valvifer plus third valvula, 23.5–27.5; third valvula 7–8.5; middle tibia, 16.5–19.5; middle basitarsus, 4.75–6; hind-tibia, 18–21.5, Male. Length, 0.63 – 0.95 mm. Similar to female except the fronto-vertex slightly broader and gaster may be nearly completely brown. Antennal scape brown, pedicel yellow to pale brown, and rest of antenna yellow to sometimes yellow brown. Antenna (Figs 3, 4) with F1 and F2 broader than long, F3 at least 1.25× as long as broad, but usually 1.5× as long as broad; in a male from Chad, F3 fully 2 × as long as broad. Relative dimensions: length (width) : scape, 34–37 (10–12.5); pedicel, 14–15.5 (8.5–9); F3, 15–17.5 (9.5–11.5); clava, 37–39 (10–11.5).

Holotype ♀, 23 ♀, 17 ♂ **paratypes,** INDIA: Andhra Pradesh, Guntur, 15.i.1967 ex *Aphis gossypii* on *Coriandrum sativum,* (M. Hayat).

Holotype and a male paratype (critical point dried and mounted on cards) deposited in the British Museum (Natural History) London. Rest of the paratypes in Hayat collection.

The following material was studied, but not included in the type series:

From Hayat collection: INDIA: Andhra Pradesh, Guntur, 2 ♀, 2♂ 20.i.1967, ex aphids on *Cajanus indicus,* (S.A.Shafee); Rajasthan, Udaipur, 1♀, 1♂ (3.x.1970, ex aphids on *Vigna catjung,* (Shuja-Uddin); Jammu & Kashmir, R. S. Pura, 2 ♀, 31. viii. 1968, ex aphids on *Sesbania* sp., (M. Hayat); Goa, Vasco-da-Gama, 2 ♀, 22. xii. 1988 (M. Hayat); Uttar Pradesh, Aligarh, 2 ♀, 1 ♂, 1969, (M. Hayat), 2 ♀, 1 ♂, 7. xii. 1978, (M. Hayat & M. Verma).

From the British Museum (Natural History) London, collection : INDIA: Andhra Pradesh, W. Godavari, 3 ♀, ? ex whitefly on cotton; Guntur, 3 ♀, ? ex whitefly on cotton; Tamil Nadu, Coimbatore, 4 ♀, 1 ♂, ix. 1982, ex *Myzus persicae* (det. by B. R. Subba Rao, as *Aphelinus kurdjumovi*); Karnataka, Bangalore, 1 ♀, 1 ♂, 19–23. ix. 1979, (J. S. Noyes); 4 ♀, vi. 1966, ex *A. gossyppii;* Kerala, Periyar Animal Sanctuary, 1 ♀, 5–15. x. 1979 (J. S. Noyes). PAKISTAN: Rawalpindi, 1 ♀, 1 ♂, ex aphids in Lab. 1967.

From the U. S. National Museum, Washington D. C., collection: INDIA: Karnataka, Bangalore, 4 ♀, 2 ♂, v. 1965, ex *Brevicoryne brassicae* on cabbage; 1 ♀; 23. iii. 1964, ex aphids on *Bacopa moniera.*

The following material received from Dr. G. Delvare, C. I. R. A. D., Montpellier, France, was identified by one of us (M.H.) as belonging to this species:

CHAD: Bebedjia, 4 ♀, 2 ♂, 31. viii. 1987, ex *A. gossypii* on cotton, (P. Silvie). PARAGUAY: Caocupe, 1 ♀, 22. i. 1985, ex *A. gossypii,* on cotton, (B. Michel).

Hosts : *Aphis gossypii* Glover ; *Aphis citricola* van der Goot; *Brevicoryne brassicae* (Linnaeus); *Lipaphis erysimi* Kaltenbach; *Myzus persicae* (Sulzer); *Rhopalosiphum maidis* (Fitch); indet. aphids on several plants. (See Ramaseshiah & Dharmadhikari, 1969, and Hayat, 1972, 1986.)

Distribution : India, Pakistan, Chad Republic, Paraguay.

Comments.– The description of *A. albipodus* sp. nov. for the material recorded earler from India under the name *A. flavipes* (Foerster), is in consequence to the synonymy of *flavipes* with *abdominalis* (Dalman) by Graham (1976), and because the Indian

specimens so identified are definitely not conspecific with *abdominalis;* There still appears to persist some confusion regarding the identity of *A. kurdjumovi* Nowicki in Mercet. Mercet (as noted from Ferriere, 1965; Nikol'skaya & Yasnosh, 1966) proposed the name *kurdjumovi* for the material supposedly misidentified as *flavipes* by Kurdjumov (1913). Ferriere (1965: p. 70) did not consider *flavipes sensu* Kurdjumov as different from *flavipes* (Foerster) as is apparent from the citations given by him. Nikol'skaya & Yasnosh (1966), on the other hand, treated *kurdjumovi* as a valid species, but in a later contribution, Yasnosh (1978) kept *flavipes* (Foerster) as a valid species with *kurdjumovi* as its synonym. This leads us to believe that it is most appropriate to follow Graham (1976) in considering *flavipes* (based on male types), and thus also *kurdjumovi,* as synonyms of *abdiominalis* because, apart from several distinguishing characters mentioned by Graham (and confirmed in my study of both Indian and British specimens), the male antennae (Fig.5) are quite distinct in having F2 only slightly broader than long about 1.5 × as long as F1, and in the setation of the fore wing (Fig. 6).

A. albipodus is very close to *varipes* (Foerster), *maidis* Timberlake and *desantisi* Hayat. It differs from *desantisi* in having the ovipositor slightly less than 1.5 × of middle tibia, and F3 in male distinctly longer than broad with long setae; from *varipes* and and *maidis* (paratype from U. S. N. M. examined) by the yellow base of the gaster and the longer F3 in male. It is thus evident that, apart from the colour of the gaster (which may at times be of low diagnostic value at the species level), it is the male that provides character for the reliable separation of *albipodus* from the three species mentioned above. In the absence of males, the larger and darker female specimens of *albipodus* may be confused with those of either *varipes* or *maidis,* though the latter two species have the hind-tibiae and sometimes also the middle tibiae, distinctly brown to dark brown. For this reason, we are unable to compare *albipodus* with *dies* Girault and *nox* Girault as both are known only from females (see Hayat & Fatima, 1990).

Aphelinus gossypii Timberlake *Aphelinus gossypii* Timberlake, 1924: 408. Female, male. U.S.A., Hawaii, Honolulu. Paratypes in the U. S. N. M. examined. *Aphelinus kashmiriensis* Hayat, 1972: 50. Female, male. India, Srinagar. **Syn. Nov.**

An error was made in the original description of *A. kashmiriensis:* the hind-femora are yellow to nearly white, not brown, and the hind tibiae are dark brown.

We have compared paratypes of *gossypii* with those of *kashmiriensis,* and consider the two species synonymous. *A. gossypii* is a widely distributed species and is a common parasitoid of *Aphis gossypii* and *related* species of aphids.

Material studied: Apart from the types of *A. kshmiriensis* listed by Hayat (1972), we have studied material collected in the Indian States of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Assam and Uttar Pradesh, from Hayat collection and the B. M. N. H. collections.

One of us (M. H.) has also identified material received from Dr. G. Delvare, C. I. R. A. D., Montpellier, France, and bred from *A. gossypii* collected in the Reunion and Guadeloupe Islands.

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CORRELATION BETWEEN FEMALE PUPAL WEIGHT AND FECUNDITY IN BIVOLTINE SILKWORM *BOMBYX MORI* L.

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The correlation of female pupal weight with fecundity was studied in bivoltine silkworm *Bombyx mori* L. Positive and highly significant correlation existed between female pupal weight and fecundity (by number and weight).

(*Key words:* *Bombyx mori* L., correlation, female pupal weight, fecundity, significant, temperate)

INTRODUCTION

The silkworm *Bombyx mori* L. has been exploited by man as it produces silk. Sericulture industry has been revolutionised in last two decades due to the research support in our country. Much emphasis is being laid presently on the sound seed organisation. There is a strong need to standardise the seed production techniques not only to get quality seeds but also the required quantity to cater to the needs of rearing programmes. In this direction, some studies have been made in silkworms regarding the relationship between pupal weight and fecundity. Positive correlation has been established between female pupal weight and fecundity by SHAMACHARY *et al.* (1980) and GOWDA *et al.* (1988) in *Bombyx mori* and NAGALAKSHMAMMA *et al.* (1988) in *Samia cynthia ricini* under tropical conditions. ROTHSCHILD (1968) observed such a relationship in a lepidopterous insect *Spodoptera mauritia*. As such studies are lacking in bivoltine silkworms reared under temperate conditions, the present experiment was undertaken to determine the relationship of female pupal weight with the fecundity for estimating the egg production by number and weight.

MATERIALS AND METHODS

Four hundred and twenty five cocoons of newly evolved bivoltine silkworm line SKUAST-1 (unreleased) of 8 days pupal age containing the pupae of assorted weights were randomly selected in summer, 1988. The cocoons were cut open for pupal sexing. The weight of 200 female pupae was recorded individually on degital electronic balance and were kept in their respective cocoon shells till moth emergence. Male pupae were not weighed as it has been studied by GOWDA *et al.* (1988) and NAGALAKSHMAMMA *et al.* (1988) that male pupal weight has no impact on fecundity. Temperature of 25 $\pm$ 1°C and R. H. of 75 $\pm$ 5% was maintained during pupal stage and oviposition. After emergence the female moths of known pupal weight were copulated randomly with male moths for 3 hours and then decoupled and kept for egg laying in cellules on egg cards of known weight. The moths were allowed to lay eggs till exhaustion. Examination of mother moths was also done to eliminate any disease effect of moths on fecundity. Fecundity was based on the number and weight of eggs laid. The data pertaining to 81 female pupae whose resultant layings were successfully

TABLE 1. Female pupal weight and its relation with egg number and egg weight

Mean of 81 observations					Correlation coefficients between	
P_w	E_n	E_w	E_n/P_w	E_w/P_w	$E_n \sim P_w$	$E_w \sim P_w$
1.459	573.5	0.336	393	0.23	0.369	0.628

P_w .. Pupal weight

E_n .. Egg number

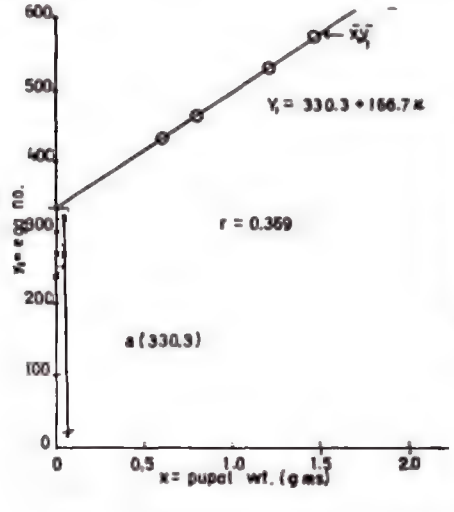
E_w .. Egg weight.

counted and weighed, were subjected to statistical analysis as per Karl Pearson's formula given by ELHANCE (1977) to study correlation coefficients between :-

a) Female pupal weight and egg number.
b) Female pupal weight and egg weight.

RESULTS AND DISCUSSION.

The female population of varying pupal weight was observed to determine its relation with actual fecundity both by number and weight of eggs. There was positive and highly significant correlation between female pupal weight and fecundity by number (r = 0.369) and weight (r = 0.268) as the table value of coefficient of correlation (r) at 1% level of significance is 0.284 (Table 1). Since relationship of fecundity with female pupal weight was significant, regression equations of egg number (Y_1) and pupal weight (X) and egg weight (Y_2) on pupal weight (X) were obtained. After getting estimated values of Y_1 & Y_2 at different values of X,linear regression lines were obtained by plotting graphs (Figs. 1 & 2). These results support the earlier investigations of SHAMACHARY *et al.* (1980) and GOWDA *et al.* (1988) on *B. mori* and NAGALAKSHMAMMA *et al.* (1988) on *S. C. ricini* under tropical conditions. Similar conclusion has been drawn by ROTHSCHILD (1968) in *S. mauritia*. Currently, a mean pupal weight of 1.459 g



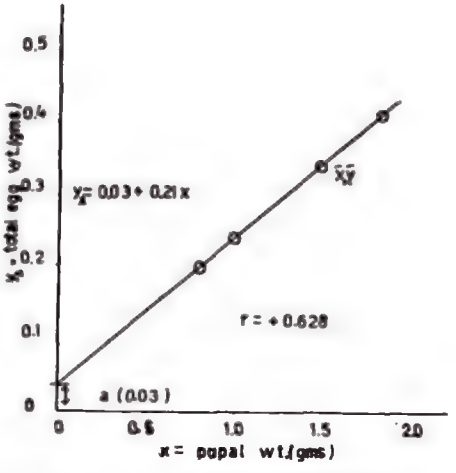


Fig. 1. (left) Regression of y_1 (egg no.) on X (Pupal wt). Fig. 2. (right) Regression of y_2 (egg wt.) on X (Pupal wt.)

produced 0.336 g of eggs by weight and 573.50 eggs by number (Table 1). It was also found that 23.02% of pupal weight was transformed into egg weight. This resembles the investigation of SHAMACHARY *et al.* (1980) on *B. mori* who obtained a ratio of 24 between egg weight and pupal weight. Moreover, from one gram of pupal weight 393 eggs could be obtained by number.

This study may help to some extent in estimating the production of exact quantity of eggs by weight and number right at the time of harvesting of cocoons on the basis of actual demand to cater to the needs of rearing programmes. This study is more pertinent for temperate climatic conditions such as prevailing in Kashmir valley and parts of Jammu region where usually single rearing schedule in spring season is followed.

ACKNOWLEDGEMENTS

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INSECTICIDAL MANAGEMENT OF THE PSEUDOSTEM BORER *ODOIPORUS LONGICOLLIS* OLIVER (COLEOPTERA: CURCULIONIDAE) IN BANANA

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Field experiment was conducted for the control of *O. longicollis* on banana. A technique of applying insecticide to ensure better contact with the insect hidden inside the pseudostem was tried. A comprehensive spraying with aldrin (0.1%) or HCH (0.3%) was found effective in managing the pest.

(*Key words:* pseudostem borer, *Odoiporus longicollis*, insecticide management)

INTRODUCTION

Banana is attacked by different insect pests among which, banana pseudostem borer *Odoiporus longicollis* Oliver is one of the important pests in Kerala. The grubs of the beetle make extensive tunnels in the pseudostem and as a result the pseudostem rots and the plant becomes weak. (VISALAKSHI *et al.*, 1989). During 1989–1990 severe incidence of this pest occurred on 'Nendran' variety of banana in Palappoor area, Trivandrum District. Repeated sprayings with different insecticides did not give adequate control of the pest as the grubs and adults were seen inside the pseudostem. The waxy coating of the banana pseudostem did not allow the insecticides to stick on the surface making the control ineffective. Therefore, another technique of application of insecticides into the leaf sheath allowing them to penetrate inside the pseudostem was tried. Thus a field experiment was conducted in an infested field to assess the efficacy of a special insecticide spraying technique for controlling the pest attack.

MATERIALS AND METHODS

The experiment was laid out in a banana field infested with pseudostem borer, *O. longicollis*. The variety was 'nendran' and the stage of the crop was one month before flowering. Plants showed varying intensities of pseudostem damage and based on the external appearance of the plant and the symptoms of damage, they were grouped into three grades. Plants showing extensive patches of tunnelling by the grubs in the pseudostem with secondary rotting at the feeding sites and a weak appearance of the pseudostem were grouped as *"heavily infested"*, plants with healthy pseudostem showing only few feeding patches were grouped as "*moderately infested*" and plants which appeared healthy without any external symptoms were grouped as *"apparantly healthy"*. A compact area consisting of 200 plants were selected and each plant was scored for the intensity of damage and tagged appropriately, sixteen plants under each grade formed one block of fortyeight plants. HCH (0.3%), monocrotophos (0.1%) and aldrin (0.1%) were the treatments and water spray served as control. Thus, each treatment was

applied on sixteen plants coming under each grade of infestation in a block. The treatments were applied in a completely randomised block design.

Insecticide suspension was prepared and spraying was done with a rocker sprayer in such a way that maximum quantity of spray fluid could be forced into the traget site. In the case of heavily infested plants, the outermost leafsheaths showing severe damage symptoms were removed and the pseudostem was cleaned before spraying. Approximately 2 litre of spray fluid was used per plant. A simple device was developed to spray down the leaf axils of 4 - 4.5 meters tall plants. The spray lance was tied tightly to a long bamboo reed and the cut off trigger was tied with a wire loop in such a way that the valve sould be kept in the fully open condition and it could be closed by sliding the loop down. The spraying operation was controlled by adjusting the rocking action of the lever. The reed-lance assembly was held with hands and the nozzle tip was directed into each leaf axil while spraying, starting from the central spindle spirally around the plant, just to the point of overflow from the leaf axil. Care was taken to avoid wastage of spray fluid. After drenching the leaf axils, the outer surface of the pseudostem was sprayed and the spray was also directed into the space within the outer leafsheaths after loosing them by gently pulling them out. Finally the base of the pseudostem and the exposed portions of the corns were also sprayed. The cut off valve was closed after finishing the spraying of each plant before moving to the next.

Observations on the percentage of plants recovered/infested were recorded 30 days after spraying and results were statistically analysed.

RESULTS AND DISCUSSION

Results of the experiment are presented in Table 1. Significant differences in the mean per cent recovery of plants infested by *O. longicollis* was observed due to the application of insecticides and the level of control obtained varied significantly among the different intensities of damage.

TABLE 1. Effect of insecticides on the recovery of banana plants infested by pseudostem weevil *O. longicollis*.

Treatments	Mean % recovery of infested plants at harvest			
	Heavily infested	Moderately infested	Apparantly healthy	Pooled mean
Aldrin (0.1%)	21.78 (27.81)	56.01 (48.43)	83.33 (65.88)	54.1 (47.37)
HCH (0.3%)	11.46 (19.78)	50.0 (44.99)	83.33 (65.88)	47.50 (43.55)
Monocrotophos (0.1%)	1.95 (8.03	44.35 (41.74)	78.51 (62.36)	36.85 (37.38)
Control	0 (0.0)	21.78 (27.81)	44.35 (41.74)	15.40 (23.18)
CD		13.64		7.88

(Values given in parenthesis are transformed values).

In heavily infested plants, application of aldrin (0.1%) could bring the highest recovery of infested plants, the per cent recovery being 21.78. HCH 0.3% also came on par with aldrin, with a mean recovery of 19.78%, while 100% damage was observed in control plants. Application of monocrotophos (0.1%) failed to show any curative effect and the recovery of infested plants was only 1.95% which was on par with that in control plants.

In the case of moderately infested plants, all the three insecticides were equally effective in controlling the pest and the mean recovery ranged from 44.35 to 56.01 per cent while in control it was only 21.78%.

In the treatments of apparantly healthy plants also, all the three insecticides proved effective in controlling the pest and 78.51 to 83.33 per cent of the plants were free of the pest at harvest while in untreated plants only 44.35% of the plants were pest free.

When the data obtained for the three different intensities of damage were subjected to a pooled analysis, a similar trend was noticed for aldrin and HCH in their efficacy in controlling the pest (54.10 and 47.5 per cent recovery respectively) followed by monocrotophos which showed a mean recovery of 36.85% which was significantly less than that of aldrin.

From the results, it is evident that aldrin (0.1%) and HCH (0.3%) can effectively check the damage by *O. longicollis* in the case of apparantly healthy and moderately infested plants if the special method of application is adopted. As both the insecticides are proved to have only contact action, this method of application will not cause any problem of residues in fruits. Since 80% of the heavily infested plants collapsed before harvest even after insecticide application, it would be desirable to recommend complete destruction of such plants rather than keeping them as a source of inoculam for further spread of the insects. It is also evident from the results that the efficacy of spraying depend on early detection of the pest incidence and a comprehensive spraying covering all the plants in the infested area including those appearing healthy, is highly essential for obtaining satisfactory control.

DUTT & MAITI (1972) reported that treatment of infested plants by Celphos tablets at the rate of 0.5 g × 3 tablets/plant controlled the egg larval, pupal and adult populations inside the psuedostem. They also reported that application of contact insecticide like endrin emulsion around the pseudostem as surface deposit or treatment of soil with soil insecticide litre aldrin dust failed to control the pest since some adults did not come out of the pseudostem and continued to multiply inside. However in the present experiment, aldrin spray was found effective in controlling the pest since the mehod adopted facilitated improved contact of the pesticide with the insect.

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BRIEF COMMUNICATION

EFFECT OF INFESTATION OF SORGHUM GRAINS BY DIFFERENT DOSAGES OF *CORCYRA CEPHALONICA* EGGS ON ADULT EMERGENCE PATTERN

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In a *Corcyra cephalonica* Stainton mass production programme, different dosages of its eggs @ 250, 500, 1000, 1500, 2000, 3000, 4000 and 5000, were infested to 1 kilogram sorghum grains in an effort to find out optimum egg ratio per kilogram of sorghum grains. Based on two improtant parameters, grain utilisation and moth emergence, a dosage of 1500 eggs per kilogram of sorguhm was found optimum. During winter months (24 ± 1°C) peak moth emergence was between 100 — 130 days of infestation whereas during summer months (29 ± 1.5°C) between 61 - 90 days.

(*Key words:* infestation, different dosages, *Corcyra cephalonica*, *emergence*)

In India *Corcyra cephalonica* Stainton is being utilised in various biocontrol research, developmental and extension units for mass production of number of natural enemies. In an attempt to minimise cost of production by optimising the grain utilisation by *C. cephalonica*, experiment was conducted to find out optimum egg numbers for infesting sorghum grains and emergence pattern during summer and winter months. The results are presented in this paper.

Sorghum grain has been found to be more suitable medium for rearing *C. cephalonica* (RAO *et al* ., 1980; SHARMA *et al*., 1982). *C. cephalonica* was reared in wooden boxes (40 × 30 × 18 cm). Twenty four such boxes were filled with 1 kg of crushed sorghum grains and were charged with *Corcyra* eggs @ 250 (0.015 cc), 500 (0.03 cc), 1000 (0.06 cc), 1500 (0.10 cc), 2000 (0.13 cc), 3000 (0.2) cc), 4000 (0.25 cc) and 5000 (0.33 cc). In another experiment, during winter and summer months rearing boxes were filled with 3 kg crushed sorghum grains and 4500 eggs per box were charged. Moth emergence was recorded regularly from 42nd day till it was fully over. Each experiment was replicated three times and data was analysed by analysis of variance. In the rearing room humidity was maintained at 68 ± 5%.

The emergence of moth started on 45th day in treatments with 250, 500, 1000, 1500, 2000 and 3000 eggs per kilogram grain. Development in greater densities of 4000 and 5000 eggs was very slow and first moth could emerge on 51st day (Table 1). In treatment of 250 eggs, moth recovery was 84.6% in comparison to 63.6% in treatment of 500 eggs but more than half of sorghum grains remained unfed. A moth recovery of 43.0, 45.5 and 12.9% was obtained in ratios of 1000, 1500 and 2000 eggs per kilogram. However, in treatment of 1000 eggs about twenty per cent grains remained unfed. With increase in egg density per kilogram of sorghum grains beyond the optimum, a diminishing return in terms of moths emerged was observed. Moth emergence ranged between 61 to

Contribution No. 51009 of Biological Control Centre, Bangalore.

TABLE 1. Emergence of *Corcyra cephalonica* moth from sorghum grain charged with different egg level

Days after charging	No. of eggs infested							
	250	500	1000	1500	2000	3000	4000	5000
45–50	30.0	17.0	12.0	18.0	14.7	3.0	0.0	0.0
51–60	70.6	50.0	23.0	33.0	16.0	7.0	7.0	1.0
61–70	17.0	28.0	25.0	82.0	11.0	2.3	12.0	3.0
71–80	24.0	49.0	80.0	121.0	26.0	9.0	4.3	4.0
81–90	17.6	43.0	88.0	146.0	21.0	10.0	5.0	4.0
91–100	9.0	48.0	86.7	119.0	45.0	4.3	3.0	2.0
101–110	5.0	13.3	49.0	76.0	45.0	7.0	6.0	7.0
111–120	8.0	16.0	45.3	34.0	29.0	16.0	8.0	6.0
121–130	10.6	18.0	8.0	24.0	12.0	4.7	18.7	18.0
131–140	10.0	10.0	5.0	18.0	7.0	4.0	11.3	11.0
141–150	10.0	5.7	8.0	12.0	11.3	1.0	6.0	5.0
Total emergence	211.8	318.0	430.0	683.0	258.0	68.3	81.3	61.0

S. Em.	Days	Eggs infested	interaction
	0.87	0.69	2.13
C.D. at 5%	2.40	1.92	6.22

TABLE 2. Mean egg laying of *Corcyra* moths emerged from various treatments.

Treatments	Meann eggs laid
250	134[a]
500	140[a]
1000	145[a]
1500	142[a]
2000	80[b]
3000	65[b]
4000	30[c]
5000	24[c]
S. Em.	5.83
C. D. at 5%	17.70
F Test	* *

Treatment means followed by same letter did not differ significantly.

81.5 in treatment with 3000 - 5000 eggs. It was also noticed that peak emergence was after 90 days and even large numbers of larvae were found to be in early instars. RAJ (1976) had reported 40 and 60% emergence when 2700 (0.17 cc) and 1350 (0.08 cc) eggs were infested to per kilogram grain. In the present study also lower emergence was observed with increase in egg infestation level.

Egg laying was 134, 140, 145 and 142 eggs per female in treatments with 250, 500, 1000 and 1500 eggs per kilogram grains (Table 2). However, in 2000 - 5000 eggs treatments moths laid 80, 65, 30 and 24 eggs per female, respectively, which is much lower in comparison to first four treatments. Less egg laying and late emergence in higher infestation level was reported by RAJ (1976).

TABLE 3. Emergence pattern of *Corcyra* moths during winter and summer months at egg – sorghum ratio of 4500 eggs : 3 kilo - gram grains.

Emergence between days	No. of moths emerged during	
	Winter 24 ± 1°C	Summer 29 ± 1.5°C
42–50	18.0	19.0
51–60	23.3	30.0
61–70	65.3	251.3
71–80	70.7	388.7
81–90	96.3	410.7
91–100	99.7	133.3
101–110	258.0	115.7
111–120	237.3	47.7
121–130	515.7	15.3
131–140	79.3	0.0
141–145	19.3	0.0
Total emergence	1482.9	1411.7
S. Em.	1.81	
C. D. at 5%	5.17	

In another experiment where moth emergence was observed during winter months (mean temperature 24 ± 1.0°C) summer months (mean temperature 29 ± 1.5°C). During winter months moth emergence continued upto 145 days with peak between 101 – 130 days as against 130 days in summer months with peak between 61 – 90 days. Moths emergence pattern differed significantly between these two seasons (Table 3).

It may be concluded that keeping in view grain utilisation and moth emergence 1500 eggs should be charged to 1 kilogram sorghum grains. During winter months rearing boxes will remain occupied for 140 days while in summer for 110 days for optimum utilisation of sorghum grains and mass production facility.

ACKNOWLEDGEMENTS

Authors are thankful to the Director, NCIPM, Faridabad for providing facilities and to Mr. C. BHARATHI DASAN for help during present study.

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BRIEF COMMUNICATION

HEMKUNTUS GEN. N. OF ALLANTINAE (HYMENOPTERA; TENTHREDINIDAE) BASED ON A NEW SPECIES FROM INDIA

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(*Received* 12 *April* 1991)

A new genus *Hemkuntus* based on a type species, *Hemkuntus religiosa* is described and illustrated. The new genus is somewhat related to *Rhopographus* Konow, from which it is clearly distinguished as clypeus is emarginate, subapical tooth of tarsal claw shorter and abdomen not constricted near its base (clypeus incised, subapical tooth as long as apical and abdomen constricted near base in *Rhopographus*). The type material will be deposited in IARI, New Delhi.

(*Key words:* *Hemkuntus*, gen. n., Allantinae, Hymenoptera, India)

Work on Indian Allantinae is quite scattered. Most of the contribution has been made by Malaise (1934, 1935, 1945, 1957, 1961). In his most outstanding and exhaustive studies, Malaise (1963) gave a key to the genera of world Selandriinae (including Selandriinae, Hetarthriinae, Allantinae, Nematinae and Blenocampinae of now a days). After this no new genus has been added to this subfamily from South East Asia. With the present new genus, the total number of genera described under Allantinae from India comes to 18.

Hemkuntus gen. n.

Type species: *Hemkuntus religiosa* sp. n.

Adult: Antenna 9 segmented, apical 3 segments subequal in length; clypeus very shallowly emarginate; mandibles subsymmetrical; lower margin of eye just below level of antennal socket; frontal area roundly elevated slightly above level of eyes; median fovea broad with flat bottom; head slightly enlarged behind eyes; tarsal claw with a long apical and shorter subapical tooth, basal lobe absent. In forewings, anal cell cross vein oblique; hind wings with two closed middle cells; anellan cell with long petiole; nervellus slightly oblique to both anellan petiole and brachiellan vein.

Distribution: India: Uttar Pradesh.

Remarks: This genus runs smoothly upto couplet 144 in Malaise's 1963 key for the genera of the world, but fails to move further as the claws are not simple and anal cell cross vein is oblique. The genus is characterised by mandibles subsymmetrical, clypeus very shallowly emarginate and hind wings with two closed middle cells.

Etymology: The genus has been named after a highly sacred place, Hemkunt Sahib, situated in the Garhwal Hills.

Gender: Feminine.

Hemkuntus religiosa sp.n.

(Figs. 1, 2, 3, 4)

Female: Average length, 10.5 mm. Head black, liver brown are: an irregular spot posterior to eye along hypothetical hind

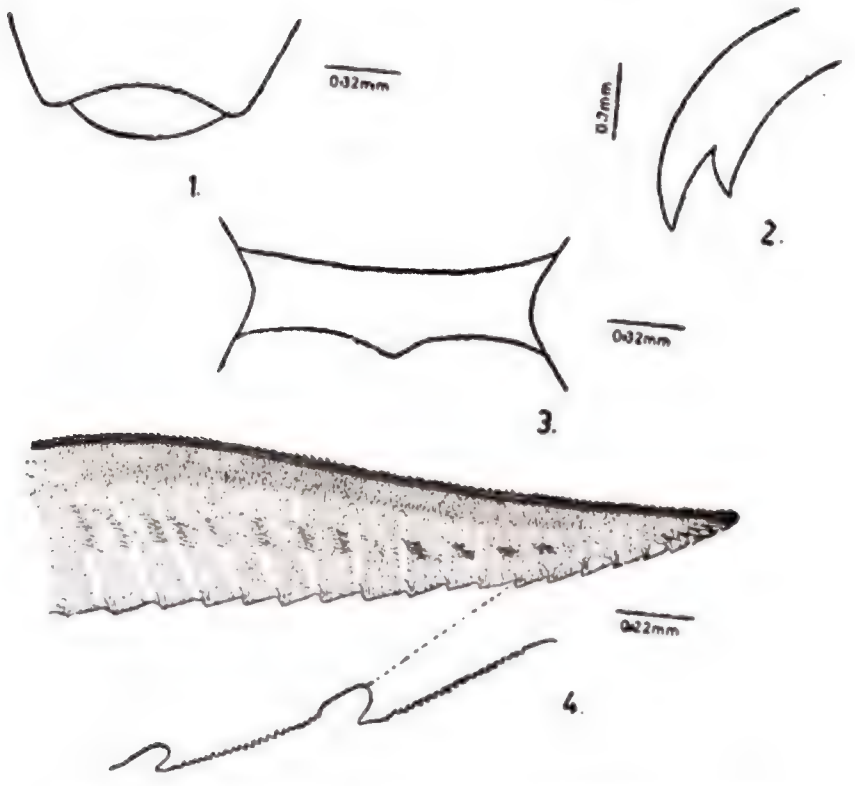

Fig. 1. Clypeus and labrum; 2. Tarsal claw; 3. Hypopygium; 4. Lancet.

margin of head. Thorax liver brown, black are: posterodorsal border and an irregular spot before anteroventral tip of pronotum; medial and lateral seams of mesonotal middle lobe; anterior slope of mesoscutellum, areas and ridges lateral to it; tegula; metanotum except spots lateral to cenchrus; mesepimeron; mesepisternum anterior to convexity; longitudinal spot along mesopleural suture; entire mesosternum; posterior border of metepisternum, metepimeron and metasternum. Abdomen liver brown, black are: broad posterior border of all sternites; visible part of sawsheath. Legs black except extreme tips of all tibiae and very narrow basal rings on all tarsal joints. Wings almost hyaline, slightly infumated towards tip; costa stigma and venation dark brown to black.

Antenna 9 segmented, 2.4 × head width, scape and pedicel longer than broad, segments 3 and 4 subequal in length, apical 3 segments subequal; clypeus (Fig. 1) very shallowly emarginate; labrum broader than long in ratio 3:2, with rounded and deflexed anterior margin; malar space .9 × diameter of median ocellus; lower margin of eye just below level of antennal socket; LID: IDMO : EL = 2.0 : 1.7 : 1.0; head without postgenal carina; supraclypeal and suprantennal pits well marked; antennal furrows deep, well marked; frontal area roundly elevated, slightly above level of eyes; median fovea broad with flat bottom; circum-, inter- and postocellar furrows well marked; lateral furrows deep, well marked and diverging posteriorly; postocellar area depressed, broader than long in ratio 3:2; head slightly enlarged behind

eyes; OOL : POL : OCL = 2.0 : 1.0 : 2.5; mesoscutellum flat with faint indication of a longitudinal carina; appendage not carinate; ICD : ITD = 1.0:3.8; mesepisternum roundly elevated without carina or acute apex; tarsal claw (Fig. 2) with a long apical and shorter subapical tooth, basal lobe absent; metabasitarsus and following joints in ratio 5.:0: 5.5; IATS: MB: OATS = 2.0:5.0:1.9.

Head coarsely and densely punctured; mesonotum very minutely punctured; mesoscutellum covered with dense microsculpture; appendage polished; mesopleuron and mesosternum punctured like head; abdomen microsculptured.

Lancet (Fig. 4) having about 20 serrulae. Each serrula is deep having numerous anterior and posterior subbasal teeth.

Hypopygium as in Fig. 3.

Male: Unknown.

Population variation: Irregular spot posterior to eye along hypothetical hind margin of head is missing; spot on pronotum reduced. Liver brown colour more extensive on legs such as: irregular spots on all coxae and irregular spots on anterior aspects of four front femora, apical 2/3 of four front tibia and all tarsi except their extreme tips, which are somewhat infumated (not black).

Holotype: Female, Utttar Pradesh: Hemkunt Sahib-3000 m, 1. vii. 1989.

Paratype: Female, Uttar Pradesh: Chopta–3000 m, 4. vii 1989.

Distribution: India: Uttar Pradesh.

Remarks: This species is characterised by subsymmetrical mandibles, malar space .9 × diameter of median ocellus and clypeus very shallowly emarginate.

Etymology: The species has been named after the highly sacred religious place, Hemkunt Sahib.

ABBREVIATIONS

EL-Eye length; IATS - Inner apical tibial spur; ICD - Interchencheri distance; IDMO - Interocular distance at levels of median ocellus; ITD - Intertegular distance; LID - Lower interocular distance; MB - Metabasitarsus; OATS - Outer apical tibial spur; OCL - Oculo-occipital line; OOL - Oculo-ocellar line; POL - Postocellar line.

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BRIEF COMMUNICATION

A RARE NEW *TEGENARIA* LATREILLE SPIDER (ARANEAE: AGELENIDAE) FROM COASTAL ANDHRA PRADESH, INDIA

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A rare new spider species *Tegenaria hemanginiae* (Agelenidae) is described in detail and illustrated from Visakhapatnam District of coastal Andhra Pradesh, India.

(*Key words:* *Tegenaria hemanginiae* sp. nov., Agelenidae, India)

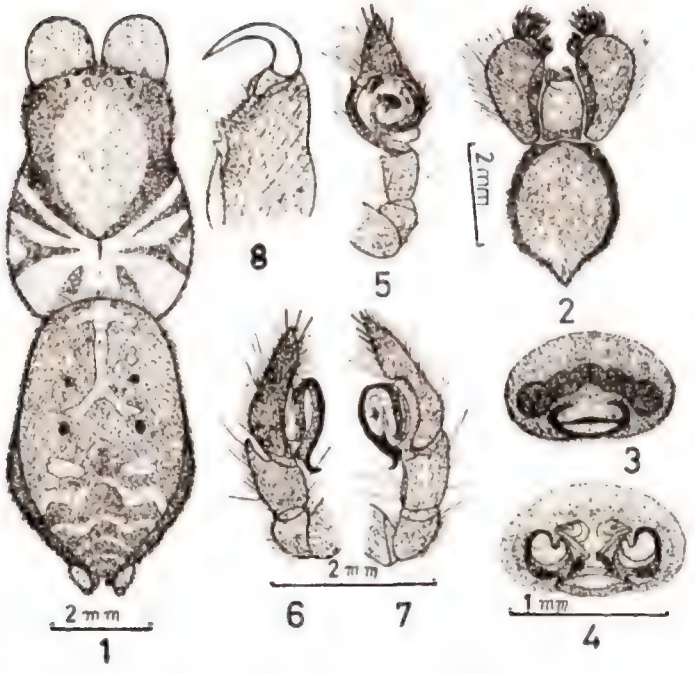
The earlier works of Cambridge (1885), Caporiacco (1935), Gravely (1927) and Simon (1889, 1897, 1906) have described all the eleven new species belonging to seven genera of the family Agelenidae from India. Out of eleven species, three were found from Karakoram (now in Pakistan). Recently Tikader (1962, 1964, 1968, 1970) reported the occurrence of the family Agelenidae and described six new species making a total of seventeen. Out of these, only three species, two of Tikader (1964, 1970) and one of Clerk (1757) are belonging to this rare genus *Tegenaria* Latreille. While examining the spider collections made from Coastal Andhra Pradesh, we came across a new species of this genus which is described and illustrated here. Both the family and the genus are being recorded for the first time from Andhra Pradesh. This is the fourth species of *Tegenaria* described from India.

The type specimens will in due course be deposited in the National Collections of Zoological Survey of India, Calcutta.

Tegenaria hemanginiae sp. nov.
(Figs. 1–8)

General: Cephalothorax and legs reddish brown, abdomen yellowish brown. Total length 10.10 mm. Carapace 5.00 mm long, 3.75 mm wide; abdomen 5. 55 mm long, 3.75 mm wide.

Cephalothorax: Longer than wide, relatively broad in front, convex, clothed with fine stiff hairs; cephalic region high, thoracic region provided with a deep fovea and radiating streaks. Eyes in two rows, all pearly white. Anterior row slightly procurved, anterior medians smaller than anterior laterals. Posterior row longer than anterior row and procurved, posterior medians slightly closer to each other than to adjacent laterals. Ocular quad slightly longer than wide, much wider behind than in front as in Fig. 1. Clypeus narrow. Sternum oval, light reddish brown, pointed behind, clothed with spiny hairs. Labium and maxillae longer than wide, reddish brown, distal ends provided with scopulae. Sternum, labium and maxillae as in Fig. 2. Chelicerae deep brown, strong and nearly vertical, inner and outer margins of fang furrow provided with seven and eight teeth respectively. The first two teeth are bigger in size and the rest are gradually decreasing in size in the outer margin as in Fig. 8. Legs robust, clothed with hairs, spines, and trichobothria. Tibiae and metatarsi of all the legs provided with three pairs of ventral spines. Tarsi of all the legs provided with a series of trichobothria. Leg formula 1 4 2 3.



Figs. 1-8. *Tegenaria hemanginiae* sp. nov. 1. Dorsal view of female (legs omitted); 2. Sternum, labium and maxillae; 3. Epigyne; 4. Internal genitalia; 5. Right male Palp - ventral view; 6. Right male palp–inner view; 7. Right male palp - outer videw; 8. Left chelicera - ventral view.

Male: Similar in size, shape and colour pattern. Total length 9.60 mm. Male palp as in Figs. 5–7.

Abdomen: Yellowish brown, longer than wide, clothed with thick hairs, slightly overlapping the posterior region of cephalothorax in front. Dorsum of abdomen priovided with two pairs of sigillae and yellow patches as in Fig. 2. Ventral side pale in colour. Anterior spinnerets are clearly separated, median and posterior are small. Epigyne and internal genitalia as in Figs. 3 and 4.

Holotype : One ♀, **paratype,** 5 ♀, *allotype,* 10 ♂ in spirit.

Type-locality: Araku valley Dist. Visakhapatnam 28. ix. 1985 and 10. x. 1986. Coll. T. S. Reddy.

Diagnosis : This species resembles *Tegenaria chhanguensis* Tikader but it is separated as follows: (i) Posterior row of eyes longer than anterior row and procurved, but in *T. chhanguensis* posterior row of eyes longer than anterior row and slightly recurved. (ii) Inner and outer margins of fang furrow provided with eight and seven teeth resp. but in *T. chhanguensis* inner margin without tooth and outer margin with a large tooth. (iii) Dorsum of abdomen provided with two pairs of sigillae but in *T. chhanguensis* without sigillae. (iv) Epigyne and internal genitalia are also structurally different.

Note: This is the fourth species so far described from India.

ACKNOWLEDGMENTS

The authors are grateful to the Principal K. B. TIPNIS, Sir P. P. Institute of Science, Bhavnagar University, Bhavnagar for the laboratory facilities. One of us (TSR) is also thankful to the Govt. of Gujarat for financial assistance.

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BRIEF COMMUNICATION

A NEW SPECIES OF *NEOSCONA* SIMON (ARANEAE: ARANEIDAE) FROM COASTAL ANDHRA PRADESH, INDIA

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A new spider species *Neoscona ujavalai* (Araneidae) is described in detail and illustrated from West Godavari District of Coastal Andhra Pradesh, India.

(*Key words:* *Neoscona ujavalai* sp. nov., Araneidae, India)

Some information is available on Indian araneid forms along with other groups of spiders from previous workers.

Till now 19 species of the genus *Neoscona* Simon are described, out of which six species by Tikader and Bal (1981) and two species by Patel and Reddy (in press) are described from India.

While examining the spider collections made by one of us (TSR) from Coastal Andhra Pradesh, we came across a new species of *Neoscona* which is described and illustrated here, which makes a total of 20 species.

The type specimens will in due course be deposited in the National collections of Zoological Survey of India, Calcutta.

Neoscona ujavalai sp. nov. (Figs. 1–5)

General: Cephalothorax and legs light yellowish brown, abdomen yellow with brown streaks. Total length 6.25 mm. Carapace 2.40 mm long, 2.05 mm wide; abdomen 4.15 mm long, 3.35 mm wide.

Cephalothorax: Longer than wide, narrowing in front, clothed with pubescence and hairs, cephalic region slightly elevated, thoracic region provided with a longitudinal fovea. Anterior median and posterior median eyes are equal in size, posterior median eyes encircled with black rings. Both rows of eyes recurved as in Fig. 1, but anterior row strongly recurved than the posterior row. Lateral eyes contiguous and situated on a black tubercle. Ocular quad longer than wide, slightly wider in front than behind. Sternum heart shaped, pointed behind pale and clothed with hairs. Labium wider than long, pale clothed with hairs. Maxillae longer than wide and distal ends provided with scopulae. Sternum, labium and maxillae as in Fig. 2. Chelicerae strong, provided with prominent boss; both inner and outer margins of fang furrow provided with three teeth each. Legs thin and long, yellowish, clothed with hairs and spines.

Abdomen: Oval, longer than wide, yellowish with brown streaks, clothed with hairs. Abdomen provided with four pairs of sigilla arranged mid-longitudinally and decorated with minute chalk-white spots. On the posterior half of abdomen a deep brown longitudinal line bifurcated after its half the length reaching upto the posterior end, with two pairs of uneven oblique lateral lines is present as in Fig. 1. Ventral side of abdomen is pale in colour and provided with three pairs of very small

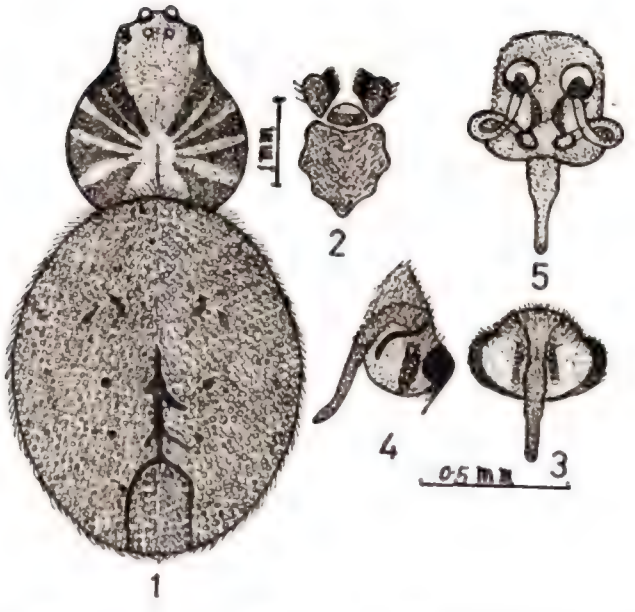

Fig. 1-5. *Neoscona ujavalai* sp. nov. 1. Dorsal view of female (legs omitted); 2. Sterum, labium and maxillae; 3. Epigyne; 4. Epigyne lateral view; 5. Internal genitalia.

reddish spots in between the epigastric furrow and spinnerets. Epigyne provided with thin and long, narrow, wrinkle scape, which bends at the middle and provided with a pair of lateral lobes as in Fig. 3 and 4. Internal genitalia as in Fig. 5.

Holotype: One ♀ in spirit.

Type-locality: Tadikalapudi, Dist. West Godavari. 1. ix. 1985,. Coll. T. S. Reddy.

Diagnosis : This species resembles *Neoscona bengalensis* Tikader and Bal but it is separated as follows:

(i) Sternum heart shaped, pointed behind, pale and clothed with hairs but in *Neoscona bengalensis* sternum heart shaped, pointed behind, brown clothed with hairs and spines and provided with mid-longitudinal pale bar. (ii) Abdomen oval, but in *Neoscona bengalensis* abdomen is sub-traingular, wider in front than behind. (iii) Epigyne and internal genitalia are also structurally different.

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The authors are grateful to Prof. K. B. TIPNIS, Principal, Sir P. P. Institute of Science, Bhavnagar University, Bhavnagar for providing the laboratory facilities.

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BRIEF COMMUNICATION

GROWTH REGULATING ACTIVITY OF BENDIOCARB, A CARBAMATE COMPOUND AGAINST MOSQUITO VECTORS, *ANOPHELES STEPHENSI* AND *CULEX QUINQUEFASCIATUS*

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(*Received 9 March* 1991)

Effect of bendiocarb, a carbamate compound on the larval and pupal stages of two mosquito vectors *Anopheles stephensi* and *Culex quinquefasciatus* was studied. It is observed that the compound disrupts the growth and development of mosquitoes when applied at sublethal doses. The compound causes larval and pupal mortality, prolonged larval and pupal periods, suppressed pupation and adult emergence and induces morphological abnormalities at all developmental stages. The results of the present investigation thus show that the compound combines the toxic, growth regulating and juvenoid action and is highly recommended for the suppression of mosquito population.

(*Key words:* Bendiocarb, growth regualting activity, mosquito vectors)

Carbamates, in addition to their insecticidal property, have been reported to show juvenoid activity against different insect pests (VOGEL *et al.*, 1979; DORN *et al.*, 1981; SCHEFER *et al.* 1985; 1987; STAAL *et al.*, 1985). Bendiocarb, an extremely active broad spectrum carbamate has been reported to possess insecticidal activity and has been rigourously used in field trials against mosquitoes (ESHGLY *et al.*, 1978; FINCHIN *et al.*, 1984; AMALRAJ *et al.*, 1986). In the present investigation the effect of sublethal concentrations of Bendiocarb on growth and development of two mosquito vectors, *Anopheles stephensi* and *Culex quinquefasciatus* has been assessed.

Mosquitoes used in the present study were obtained from a laboratory culture of *A. stephensi* and *C. quinquefasciatus* maintained at 28 $\pm$ 2 degree celsius and 80 $\pm$ 5% r. h.

Bendiocarb was diluted with acetone to obtain 1% (V/V) standard stock solution. Final concentrations of 0.0001, 0.00001 and 0.00005 ppm were prepared by further diluting the stock solution with required amount of distilled water. To assess the growth regulating action of the compound, 100 second instar larvae of each mosquito species were treated with different concentrations. Four replicates, each with 25 larvae were run along with a control of solvent alone. Powdered yeast was provided as food and test formulation was changed on alternate days to avoid decay. The observations were continued till the adult emergence.

Results recorded in the present investigation are presented in Table 1. It is reported that the compound is highly effective in disrupting the growth and development of *A. stephensi* and *C. quinquefasciatus*. A dose-dependent effect on larval and pupal mortality is observed. Maximum larval mortality of 44.0 percent is observed on treating second instar larvae of *A. stephensi* at 0.0001 ppm as compared to only 14.00 percent mortality at 0.00001 ppm. A high mortality recorded on

TABLE 1. Efffect of Bendiocarb on larval and pupal instars of *A. stephensi* and *C. quinquefasciatus*.

Mosquito species & Doses (ppm)	Percent mortality during different larval instars			Total larval mortality (%)	Percent pupal mortality	Percent total mortality	Average larval period (days)	Average pupal period (days)	Percent adult emergence	Average development preiod (days)
	II*	III	IV							
Anopheles stephensi										
0.0001	20	14	10	44.00	3.00	47.00	26.13 ± 1.00	8.88 ± 1.03	50.00	35.01 ± 1.34
0.00005	10	8	5	23.00	1.00	24.00	20.38 ± 1.25	6.23 ± 1.12	76.00	26.61 ± 1.03
0.00001	8	4	2	14.00	2.00	16.00	16.23 ± 1.03	4.89 ± 0.67	80.00	21.12 ± 1.12
Control	2	—	—	2.00	0.00	2.00	14.40 ± 1.15	3.40 ± 1.05	98.00	17.80 ± 1.15
Culex quinquefasciatus										
0.0001	24	10	9	43.00	6.00	49.00	28.32 ± 1.13	9.90 ± 1.11	51.00	38.22 ± 0.99
0.00005	14	9	3	28.00	3.00	31.00	22.00 ± 1.13	7.55 ± 1.06	69.00	29.55 ± 1.03
0.00001	10	6	—	19.00	0.00	19.00	17.21 ± 1.23	3.80 ± 1.12	81.00	21.01 ± 1.12
Control	—	—	—	0.00	0.00	0.00	14.43 ± 0.89	3.38 ± 1.03	100.00	17.81 ± 1.23

* 100 second instar larvae were treated at each dose level.

treating larvae of *C. quinquefasciatus* at the same dose levels indicate that it is more susceptible than *A. stephensi.*

Earlier instars are reported to be more susceptible than the later ones in both the sepecies of mosquito. As compared to fourth instar a low percent mortality observed for pupae is indicative of the fact that pupae are less sucesptible than the fourth instar larvae.

A marked prolongation of larval and pupal periods is observed at all the doses applied. Maximum prolonged larval period of 26.13 days is recorded at 0.0001 ppm on treating 2nd instar larvae of *A. stephensi* as compared to 14.40 days in control. Similarly on treating *C. quinquefasciatus* larvae, a maximum prolonged larval period of 28.32 days is recorded as compared to 14.43 days in control. Pupal period is also significantly prolonged at all the doses applied. Both the species are affected; *C. quinquefasciatus* being slightly more susceptible.

A significant fall in the emergence of adults on treating 2nd instar larvae of *A. stephensi* and *C. quinquefasciatus* is observed. Maximum reduction is reorded at 0.0001 ppm where only 34 percent adults emerge as compared to 99.00 percent in control on treating *A. stephensi* and 51.00 percent adult emergence is observed on treating *C. quinquefasciatus* larvae at 0.0001 ppm as compared to 100 percent in control. Average developmental period is also prolonged significantly; the maximum prolonged period of 38.72 days compared to 17.81 days in control is observed on treating 2nd instar laravae of *C. quinquefasciatus* at 0.0001 ppm.

It is observed that Bendiocarb induces a number of morphological abnormalities in different developmental stages. These include death during moulting, splitting of cuticle at different regions of body, larval-pupal intermediates, loosening of appendages in pupa due to ruptured cuticle and abnormal adult emergence.

From the results obtained, it can be suggested that Bendiocarb involves a combination of growth regulating, chitin synthesis inhibitor and toxic action. The disruption in growth and development leading to prolongation in larval and pupal periods and suppression of pupation and adult emergence may be due to imbalance caused in growth stimulating and growth inhibiting hormones as is also reported previously (NOVAK, 1966; VOGEL *et al.*, 1979). VOGEL *et al.* (1979) reported inhibition of both ecdysis and metamorphosis, delayed and abortive ecdysis, larval-pupal intermediates, defective metamorphosis and adult emergence due to treatment with insect growth regulators. Abnormal development and growth in mosquitoes treated with bendiocarb is probably due to its action similar to the juvenile hormone analogues as also reported by earlier workers (SHAEFER *et al.*, 1985; AMOS *et al.*, 1978; KRAMER *et. al.*, 1981; PICOLLO DEVILLAR *et al.*, 1987).

It is thus apparent from the results that Bendiocarb is highly effective against developmental stages of mosquitoes, *A. stephensi* and *C. quinquefasicatus*. The compound in addition to its toxic action also exhibits properties of a juvenoid, and successfully disrupts growth and development when applied at sublethal doses. It thus warrants for use against mosquito populations.

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BRIEF COMMUNICATION

A NEW WHITEFLY *ALEUROTRACHELUS SAKLESPURENSIS* SP. NOV. (ALEYRODIDAE: HOMOPTERA) FROM INDIA

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A new species of whitefly *Aleurotrachelus saklespurensis* infesting *Dimocarpus longon* Lour. (Sapindaceae) in Saklespur, Karnataka State, is described and illustrated.

(*Key words: Aleurotrachelus saklespurensis, Dimocarpus longon*, Aleyrodidae)

Aleurotrachelus saklespurensis sp. nov. (Figures 1–3)

Pupal case: White, glassy, broadly oval, a thin layer of wax around margin, found on the lower surface of leaves near veins only; 0.64–0.88 mm long and 0.52–0.64 mm wide.

Margin: Regularly toothed, 18–21 teeth in 0.1 mm. Thoracic and caudal tracheal pores and combs absent. Paired anterior and posterior marginal setae 17.5–25 and 20–35 μm long respectively.

Dorsal surface: Five pairs of dorsal setae-cephalic setae 82.5–107.5 μm long, meso-thoracic setae 100–105 μm long, meta-thoracic setae 100–102.5 μm long, eighth abdominal setae 80–85 μm long and submarginal caudal setae 27.5–35 μm long. First abdominal setae wanting. Sub marginal lines evident. Cephalothorax with a longitudinal ridge on each side with numerous microtubercles present. Rhachis well developed in abdominal segments 1–6. Median tubercles on abdominal segments 1–6 prominent. Submedian pockets evident on all segment sutures. Longitudinal moulting suture reaches margin whereas transverse moulting suture reaches the subdorsum. Numerous pores and porettes sparsely distributed throughout dorsum.

Vasiform orifice cordate shaped, longer than wide, 45–52.5 μm long and 37.5–45 μm wide; operculum similarly shaped, as long as wide (22.5–30 μm). Lingula tip exposed, capitate and setose. Thoracic and caudal tracheal furrows absent.

Ventral surface: Paired ventral abdominal setae 17.5 - 27.5 μm long and 45–47.5 μm apart. Antenna very short reaches near the base of prothoracic leg.

Host: Dimocarpus longon Lour. (Sapindaceae)

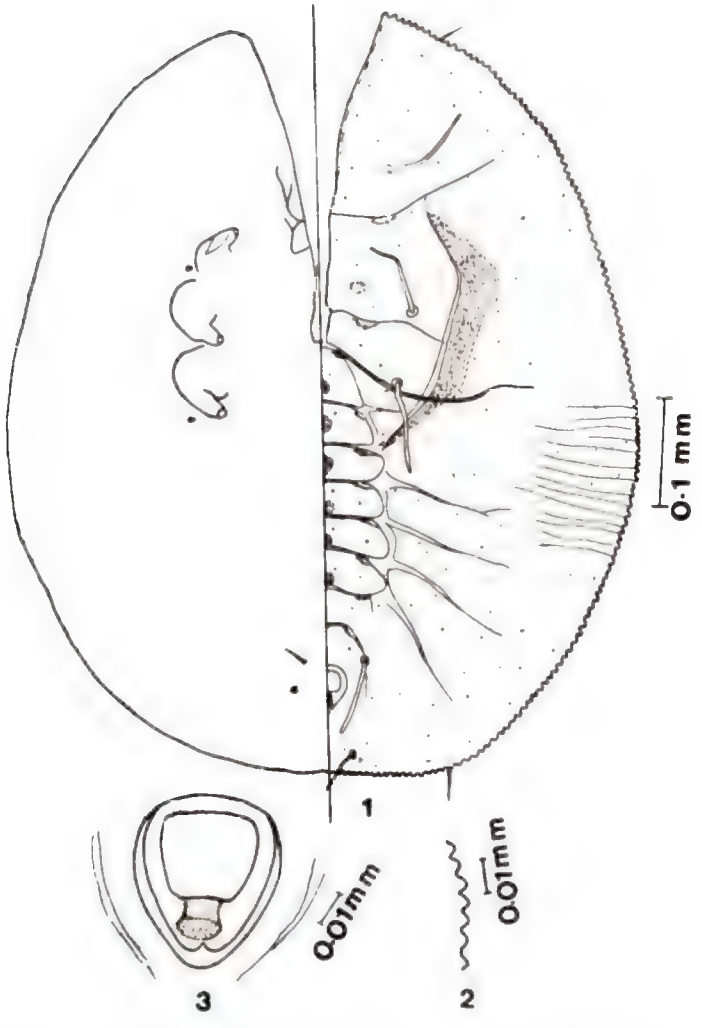
Material examined: **Holotype:** One pupal case mounted on slide, on *Dimocarpus longon*, Saklespur, 10.iii.1990, K. Regu.

Paratypes: Eight pupal cases on slides bearing the same details as of holotype.

This species resembles *Aleurotrachelus longispinus* Corbett but differs by exposed and knobbed lingula tip and shape of the pupal case.

ACKNOWLEDGMENT

Thanks are due to Dr. M. R. SUDARSHAN, Scientist, Indian Cardamom Research Institute, Saklespur for identifying the host plant and to Mr. S. JAMES FREDRICK, Chairman, FIPPAT for facilities provided.



1. Pupal case of *Aleurotrrachelus saklespurensis* sp. nov. 2. Margin; 3. Vasiform orific.

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REPORTS AND NEW RECORDS

RECORD OF NEW EGG PARASITES (SCELIONIDAE : HYMENOPTERA) OF *CANTHECONA FURCELLATA* WOLF (PENTATOMIDAE : HEMIPTERA)

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***Psix striaticeps* Dodd. (Scelionidae: Hymenoptera) and *Trissolcus* nr. *aloysiisabaudiae* Fouts. were recorded and identified as natural enemies on the eggs of *Canthecona furcellata* Wolf., a serious pest of tasar silkworm (*Antheraea mylitta* Drury). The predominance of females over males was found in each sample of *Psix striaticeps* and *Trissolcus* sp. The developmental period from egg to adult varies from 10-11 days in *P. striaticeps* and 9-11 days in *Trissolcus* sp.**

(*Key words:* *Psix striaticeps*, *Trissolcus* sp., *Canthecona furcellata*, parasites.)

Canthecona furcellata Wolf. is an important predator of young tasar silkworm (Singh, 1986). While working on the ethology of the pentatomid bug *C. furcellata* (Pentatomidae: Hemiptera) the authors came across the incidence of two species of scelionids parasitising the egg mass of *C. furcellata.* The two natural enemies were recorded and identified. The parasites are *Psix striaticeps* Dodd. (Scelionidae; Hymenoptera) and *Trissolcus* sp. nr. *aloysiisabaudiae* Fouts. These parasites were observed to parasitise the egg mass of *C. furcellata.* They were cultured in the laboratory on the egg mass (Morrison and King, 1976). Diluted honey was provided as food. Average temperature and humidity recorded in the laboratory were 28 ± 2°C and $70\pm15\%$ R. H. respectively.

One pair of male and female of each species was released separately, each pair on one fresh unparasitised egg mass. It was interesting to observe that the females of *P. striaticeps* developed successfully and parasitised the complete egg mass within 24 hours and yeilded 98 to 100% adult parasitoid within an average of 10–11 days. The sex ratio was found to be 2.62 to 3.16 females per male. Similarly in case of *Trissolcus* sp. the mated females parasitised the host egg mass within 24 hours, and the developmental period varied from 9–11 days, and the male and female sex ratio was 1:3. (Viktrov and Kochetova, 1973). In both the sepcies the sex ratio was female biased and the adult parasitoids emerged by rupturing the host egg shell.

There are numerous scelionid species that are widely distributed and all are egg parasites, most often of Lepidoptera: Hemiptera and Orthoptera (Javahery, 1968; Channa Basavanna, 1953). But these two species are for the first time being reported as egg parasites of *C. furcellata.*

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The authors are very much thankful to Dr. K. M. Harris, Director, British Museum, London, for the identification of the parasites.

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REPORTS AND NEW RECORDS

INCIDENCE OF *DROSICHA MANGIFERAE* (GREEN) (HOMOPTERA: MARGARODIDAE) ON *CANNABIS SATIVA* L. (CANNABINACEAE)

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(*Received* 28 *October* 1990)

***Cannabis sativa* has been reported as a host plant of *Drosicha mangiferae* for the first time.**

(*Key words: Drosicha mangiferae*, *Cannabis sativa*, host plant)

The giant mealy bug *Drosicha mangiferae* (Green) is a pest of mango and other fruit trees and forest trees in Northern and Central India. It has been reported to infest as many as 75 host plants, majority of which are trees or perennials (Rahman and Latif, 1944; Tanden *et al.*, 1978; Abraham and Remamony, 1979; Varshney, 1985; Chandra, 1989).

Information on *D. mangiferae* from Kerala is meager. However, Abraham and Remamony (1979) have reported it as a pest of cocoa from Kerala, during November-December. Occurrence of the insect was noticed on hemp *Cannabis sativa* L., which is an annual plant, in Bisonvalley Panchayat in Idukky District of Kerala. The infestation was noticed during March-May, 1990. Bisonvalley is a high range region at an altitude of approximately 1050 m above the mean sea level. The locality has a wealth of forest trees and shrubs. The insect was found on hemp plants in a noman's field without any mango tree nearby. Adults and nymphs were found to suck sap from the tender twigs. Maximum infestation of six adults per plant was observed.

This is the first report of *C. sativa* as a host plant of *D. mangiferae*.

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